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An illustrated key to tadpoles occurring in the Central Amazon rainforest, Manaus, Amazonas, Brasil

by

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Abstract

A key to tadpoles occurring in a Central Amazon rainforest is presented. Identification is facilitated by drawings of the mouth parts and the dorsal, lateral and ventral aspects of each species. Colour descriptions and life history notes are included to assist identification in the field. The ecological characteristics of the tadpole community are discussed.

Keywords: Anura, tadpoles, Amazon, ecology, key.

Resumo

Apresenta-se uma chave para identificação de girinos que ocorrem em uma floresta tropical úmida na Amazônia Central. Para facilitar o reconhecimento, inclui-se desenhos das peças bucais e do aspecto dorsal, lateral e ventral de cada espécie, assim como a descrição de cores e aspectos da história natural, para permitir a identificação no campo. Discute-se as características ecológicas da comunidade de girinos.

Introduction

While much is known about the herpetofauna of the central Amazon, taxonomic keys to the fauna are lacking. Difficulties in identification of the fauna is a major constraint to the conservation and management of this important habitat. The following key was constructed to provide a means of identifying the tadpoles that occur in rainforest habitat of the Manaus region. Species composition, reproduction and habitat characteristics were determined from detailed studies in Reserva Florestal Adolfo Ducke (RFAD).

The RFAD is a 10,000 ha forestry reserve 25 km north of Manaus, Amazonas, Brasil ($02^{\circ} 55'S$, $59^{\circ} 59'W$, Figure 1). The RFAD is well described in PENNY & ARIAS (1982). The vegetation consists of "terra firme" rainforest, a well drained forest not subject to seasonal inundation (GUILLAUMONT 1987). At RFAD, the "terra firme" landscape is hilly with a gradient from sandy soil in the lower creek beds to clay soil on the ridgetops (approx. 50 m higher than the creek beds). The climate is characterized by distinct wet and dry seasons, most of the rains falling between December and May (RIBEIRO & ADIS 1984; Figure 2). The mean annual rainfall at RFAD between 1965 and 1980 was 2362 mm (MARQUES-FILHO et al. 1981). Sporadic heavy rains throughout the wet season often cause the small streams to overflow their banks for several hours inundating streamside ponds.

The information herein was collected during a 3 year ecological study of anuran reproduction at RFAD, the details of which will be published separately. In that study, 12 waterbodies (2 streams, 8 streamside ponds and 2 isolated forested ponds) were sampled intensively between January 1985 and December 1987. Sites were selected to cover the range of habitats available and contained most of the anuran species known to occur in the area. Casual observations were also made on various other ponds throughout the RFAD and in open and disturbed areas.

Additional information and tadpoles were generously provided by Barbara Zimmerman during her intensive studies at the INPA/World Wildlife Fund, Minimum Critical Size of Ecosystems Project (MCSEP) Reserves approximately 50 km north of RFAD and 80 km north east of Manaus (Figure 1; see ZIMMERMAN & RODRIGUES 1990 for further details).

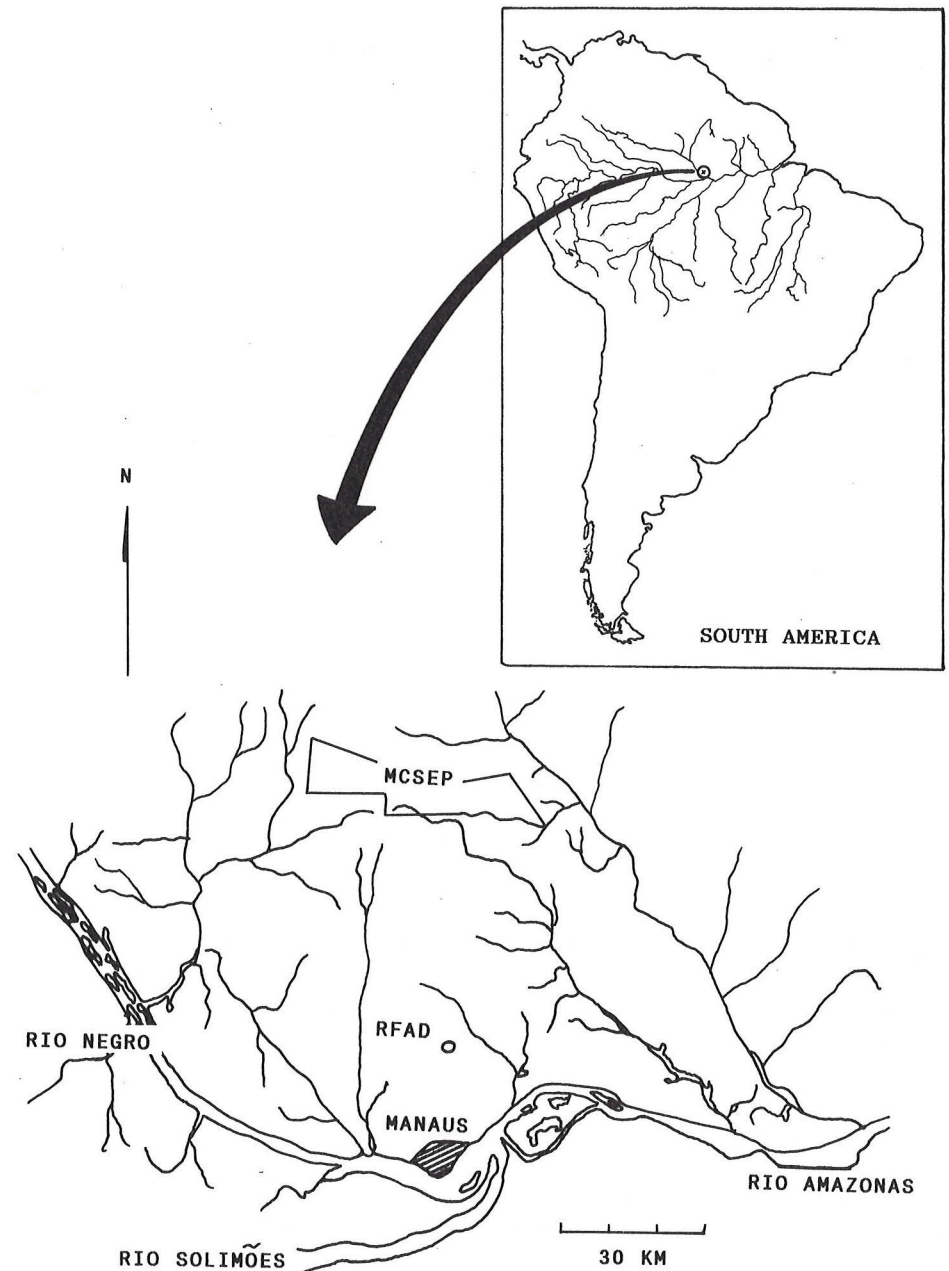


Fig. 1:
Proximity of Reserva Florestal Adolfo Ducke (RFAD) and the WWF/INPA Minimum Critical Size of Ecosystems Project (MCSEP) Reserves to Manaus, Amazonas, Brasil.

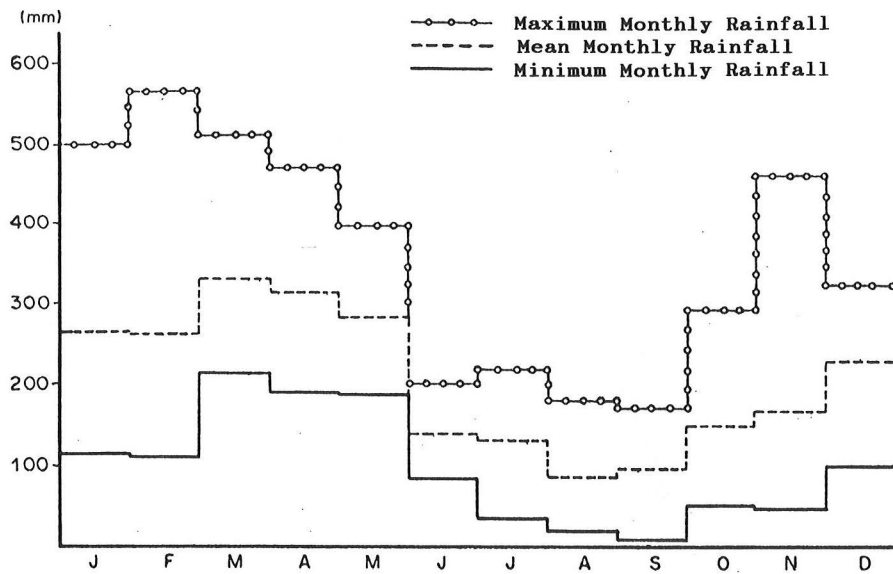


Fig. 2:
Precipitation at RFAD, monthly means, maxima and minima for the period 1965 - 1980
(MARQUES-FILHO et al. 1981).

Tadpole Descriptions

Tadpoles were identified either by growing them into an identifiable frog or by observing egg deposition and raising the eggs into tadpoles. Terminology follows ALTIG (1970) and JOHNSTON & ALTIG (1986), and I have included a glossary of terms modified from those papers. Figures 3 and 4, also from ALTIG (1970), illustrate body measurements and mouthparts. Tadpoles described are in developmental stages 25 through 42 (GOSNER 1960). For rapid identification and to confirm keyed animals I have provided drawings of each species. The drawings depict melanic patterns that persist in preserved specimens (10 % formalin) and are accompanied by brief descriptions of colour patterns in life. Habitat and life history notes also are presented when available to assist identification in the field. However, these are intended as a guide only and tadpoles may be found in different habitats and seasons than those given.

Drawings of each species were made of a single specimen that was placed in the Museu Nacional, Rio de Janeiro, Brasil (MNRJ). The size, stage, and museum number of each specimen used is provided with the drawings. The labial tooth row formula (LTRF) included with the design is based on observations of as many specimens as possible at stages 25 through 42 (GOSNER 1960). Additional specimens and their museum numbers (MNRJ) can be found in Appendix 1.

There is considerable individual, geographic and ontogenetic variation in some tadpole characteristics (ALTIG 1970), and individuals may not always be keyed correctly. Whenever possible, several tadpoles in advanced developmental stages (30 - 38) should be examined. Specimens should be preserved and maintained in 10 % formalin (ALTIG 1970).

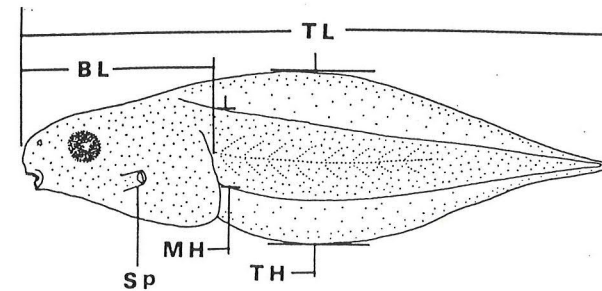


Fig. 3:
Left lateral view of a typical tadpole.
BL, body length; MH, musculature
height; TH, tail height; TL, total length.
Reprinted from ALTIG (1970).

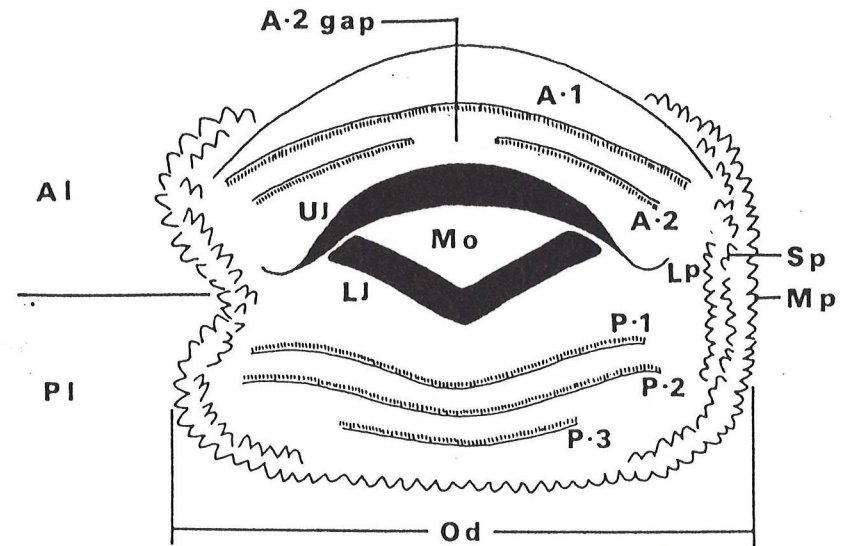


Fig. 4:
Schematic drawing of tadpole mouthparts. The left side is emarginate, the right not emarginate.
Al, anterior labium; A-1, first anterior tooth row; A-2, second anterior tooth row; Lj, lower jaw;
Lp, lateral process of upper jaw; Mo, mouth; Mp, marginal papilla; Od, oral disc; Pl, posterior labium;
P-1, first posterior tooth row; P-2, second posterior tooth row; P-3, third posterior tooth row;
Sp, submarginal papilla; Uj, upper jaw. Reprinted with permission from ALTIG (1970).

Caution should be taken with colour descriptions as colour is often a function of water clarity (BRAGG 1957). Some species of *Leptodactylus* and *Phyllomedusa* acquire a muddy grey colour when developing in the turbid waters of isolated forest ponds and are dark brown if found in clear water ponds. Species easily confused in the field include *Leptodactylus rhodomystax*, *L. wagneri* and *Hyla geographica*; *Phyllomedusa bicolor* and *P. vaillanti*; *Phyllomedusa tarsi* and *P. tomopterna*; *Bufo marinus* and *B. granulosus*; and *Colostethus marchesianus*, *Dendrophryniscus minutus* and *Epipedobates femoralis*.

The taxonomy of Amazonian Anura is in a state of flux, and some scientific names will undoubtedly change. Voucher specimens of adults of the species described in this key have been placed in the Museu Nacional, Rio de Janeiro (MNRJ) and Museu Paraense Emilio Goeldi, Belém, Pará (MPEG). The museum numbers for these specimens are included in Appendix 2. *Osteocephalus* sp. is a small brown frog that is probably undescribed (W. E. DUELLMAN, M. HOOGMOED & J. LESCURE pers. comm.) and was referred to as *Osteocephalus buckleyi* by ZIMMERMAN (1983), ZIMMERMAN & BIERREGAARD (1986), and ZIMMERMAN & RODRIGUES (1990). *Osteocephalus buckleyi* is a small greenish frog which occurs along streams (DUELLMAN 1978; M. HOOGMOED pers. com.). The status of the frog *Bufo* cf. *typhonius* currently is under revision (M. HOOGMOED pers. com.). This species has also been referred to as *Bufo dapsilis* (ZIMMERMAN & BIERREGAARD 1986). The tadpole herein described as *Chiasmocleis* cf. *ventrimaculata* has been tentatively identified as that species by ULISSES CARAMASCHI at the MNRJ and has recently been referred to as *Chiasmocleis* sp. (*hudsoni* group) by ZIMMERMAN & RODRIGUES (1990). *C. cf. ventrimaculata* is a small frog that calls from under the leaf litter beside streamside ponds. The tadpoles herein described as *Hyla* cf. *nana* and *H. cf. parviceps* were identified from the literature as they are similar to the tadpoles described by BOKERMANN (1963) and DUELLMAN & CRUMP (1974), respectively. The tadpole described as *Odontophrynus* sp./*Proceratophrys* sp. was collected by B. ZIMMERMAN at the MCSEP Reserves; to date no adults of either genus has been found in the Manaus region. However, the tadpole closely resembles those tadpoles described for other species in those genera (see CARAMASCHI 1979; PEIXOTO & CRUZ 1980; PEIXOTO et al. 1981). DUELLMAN & LESCURE (1973) described the tadpoles of *Hyla geographica* as *Osteocephalus taurinus*. The frog herein referred to as *Epipedobates femoralis* was previously *Dendrobates femoralis* (MYERS 1987).

The taxonomic status of *Leptodactylus pentadactylus* and *L. knudseni* in central Amazonia is inconsistent with published descriptions from other areas (HERO & GALATTI 1990). Two distinct species occur sympatrically in the RFAD rainforest habitat. Published descriptions of *L. pentadactylus* tadpoles (BREDER 1946; KENNY 1969; DUELLMAN 1978) closely resemble the description for *L. knudseni* herein. The true tadpole of *Leptodactylus pentadactylus* is described for the first time. The tadpoles described were grown into identifiable adults that clearly represented these two species in central Amazonia.

A computerised key to the species included in this paper has also been prepared (Appendix 3) and information on its use is available from J.-M. HERO. The computer program is flexible and can be modified to include additional tadpole characteristics and species.

Community Characteristics

During this study, 42 species of anura were found within the RFAD Reserve and additional 10 species were found by B. ZIMMERMAN in the MCSEP Reserves (Table 1). Two species commonly found in the city of Manaus also are included as they may invade rainforest habitat with disturbance and an additional tadpole species is described from this group (Table 1). An unidentified hylid tadpole (*Hyla* sp. 1) is included and probably represents one of the hylid frogs in Table 1, of which, the tadpoles are unknown. Eleven additional species of Anura from the Manaus region, not associated with rainforest habitat, were noted by HÖDL (1977). Tadpoles of the terrestrial developing *Synapturanus* sp., *Adenomera andreae* and *Leptodactylus pentadactylus* also are described as they could be washed into a waterbody with heavy rains. A total of 54 species are known to be associated with primary rainforest and 36 tadpoles are included in the following key and species descriptions (Table 2).

Table 1: List of Anura encountered at the RFAD and MCSEP Reserves (Local).

Reproductive mode (R.M.) as per DUELLMAN & TRUEB (1986), ? indicates reproductive mode not observed. Tadpole habitats are; TD = terrestrial development, St = stream, SP = streamside ponds, IP = isolated forest ponds, Ar = arboreal and Op = open and disturbed areas. Within each habitat category, x = microhabitat unknown, W = tadpole in water column (pelagic) and L = tadpole in leaf litter (benthic).

Species	Local Collected	R. M.	TD	Habitat St	SP	IP	Ar	Op
BUFONIDAE								
<i>Atelopus pulcher</i>	MCSEP	2		x				
<i>Bufo granulosus</i>	RFAD	1,2						W
<i>Bufo marinus</i>	RFAD	1,2						W
<i>Bufo</i> cf. <i>typhonius</i>	RFAD	1			L			
<i>Dendrophryniscus minutus</i>	RFAD	13			L			
CENTROLENIDAE								
<i>Centrolenella oyampiensis</i>	RFAD	18		L				
DENDROBATIDAE								
<i>Colostethus marchesianus</i>	RFAD	14			L	L		
<i>Colostethus</i> sp.	RFAD	15	x					
<i>Epipedobates femoralis</i>	RFAD	14				L		
HYLIDAE								
<i>Hyla boans</i>	RFAD	2,3		W				W
<i>Hyla</i> cf. <i>brevifrons</i>	MCSEP	?						
<i>Hyla geographica</i>	RFAD	1,2		W	W			
<i>Hyla granosa</i>	RFAD	1,2		L	L			
<i>Hyla lanciformis</i>	RFAD	?						x

Table 1: Continuation

Species	Local Collected	R. M.	TD	St	Habitat SP	IP	Ar	Op
HYLIDAE								
<i>Hyla minuta</i>	RFAD	1						x
<i>Hyla cf. microcephala</i>	MCSEP	1						
<i>Hyla cf. nana</i>	RFAD	1			W			
<i>Hyla cf. parviceps</i>	MCSEP	?						
<i>Hyla sp. 1</i>	MCSEP	?						
<i>Ololygon cruentomma</i>	RFAD	1						x
<i>Ololygon garbei</i>	RFAD	?						
<i>Ololygon cf. rubra</i>	RFAD	1						W
<i>Osteocephalus buckleyi</i>	RFAD	2		x				
<i>Osteocephalus taurinus</i>	RFAD	1			W	W		
<i>Osteocephalus sp.</i>	RFAD	4					W	
<i>Phrynohyas coriaceae</i>	MCSEP	?						
<i>Phrynohyas resinifictrix</i>	RFAD	4					W	
<i>Phyllomedusa bicolor</i>	RFAD	18			W	W		
<i>Phyllomedusa tarsius</i>	RFAD	18				W		
<i>Phyllomedusa tomopterna</i>	RFAD	18				W		
<i>Phyllomedusa vaillanti</i>	RFAD	18			W			
LEPTODACTYLIDAE								
<i>Adenomera andreae</i>	RFAD	22	x					
<i>Ceratophrys cornuta</i>	MCSEP	1				x		
<i>Eleutherodactylus fenestratus</i>	RFAD	17	x					
<i>Eleutherodactylus sp. 1</i>	RFAD	17	x					
<i>Eleutherodactylus sp. 2</i>	RFAD	17	x					
<i>Leptodactylus fuscus/longirostris</i>	RFAD	21						L
<i>Leptodactylus knudseni</i>	RFAD	21			L	L		
<i>Leptodactylus mystaceus</i>	RFAD	21				L		
<i>Leptodactylus cf. ocellatus</i>	MANAUS	8						W
<i>Leptodactylus pentadactylus</i>	RFAD	22	x					
<i>Leptodactylus rhodomystax</i>	RFAD	21			L	L		
<i>Leptodactylus riveroi</i>	RFAD	?						
<i>Leptodactylus stenodema</i>	RFAD	22	x					
<i>Leptodactylus wagneri/podicipinus</i>	RFAD	21						x
<i>Lithodytes lineatus</i>	RFAD	?						
<i>Odontophrynus/Proceratophrys sp.</i>	MCSEP	?				x		
MICROHYLIDAE								
<i>Chiasmocleis cf. shudikarensis</i>	MCSEP	?				x		
<i>Chiasmocleis cf. ventrimaculata</i>	RFAD	?			L			
<i>Ctenophryne geayi</i>	MCSEP	?						
<i>Elachistocleis ovalis</i>	MANAUS	?						
<i>Synapturanus mirandaribeiroi</i>	RFAD	15	x					
<i>Synapturanus salseri</i>	RFAD	15	x					
PIPIDAE								
<i>Pipa pipa</i>	RFAD	11						
<i>Pipa arrabali</i>	MCSEP	11						
TOTAL		54	9	6	12	12	2	10

Many of the tadpoles described in this paper have been described in other areas of South and Central America (Table 2). In particular the works of KENNY (1969) and DUELLMAN (1978) should be consulted. A summary of major characteristics for each species described in the literature is presented in ALTIG & JOHNSTON (1986). Eight species are herein described for the first time *Centrolenella oyampiensis*, *Hyla sp. 1*, *Osteocephalus sp.*, *Phrynohyas resinifictrix*, *Phyllomedusa bicolor*, *Leptodactylus knudseni/pentadactylus*, *Chiasmocleis cf. ventrimaculata* and *C. cf. shudikarensis*.

Table 2: List of tadpole descriptions found in the literature; * indicates that the species is described herein and included in the dichotomous key, DD indicates that the species has direct development and no free-living tadpole stage, and TD indicates that the species has totally terrestrial development in an isolated nest or burrow.

Species	Published descriptions
BUFONIDAE	
<i>Atelopus pulcher</i>	GASCON 89
<i>Bufo granulosus</i>	* KENNY 69
<i>Bufo marinus</i>	* BREDER 46; SAVAGE 60; KENNY 69; DUELLMAN 78
<i>Bufo cf. typhonius</i>	* DUELLMAN 78
<i>Dendrophryniscus minutus</i>	* DUELLMAN & LYNCH 69; DUELLMAN 78
CENTROLENIDAE	
<i>Centrolenella oyampiensis</i>	*
DENDROBATIDAE	
<i>Colostethus marchesianus</i>	* EDWARDS 74; DUELLMAN 78
<i>Colostethus sp.</i>	TD FLORA ACUNA JUNCA pers. comm.
<i>Epipedobates femoralis</i>	* LESCURE 76; SILVERSTONE 76; DUELLMAN 78
HYLIDAE	
<i>Hyla boans</i>	* DUELLMAN 70, 78
<i>Hyla cf. brevifrons</i>	DUELLMAN & CRUMP 74; DUELLMAN 78
<i>Hyla geographica</i>	* KENNY 69; DUELLMAN & LESCURE 73; DUELLMAN 78
<i>Hyla granosa</i>	* DUELLMAN 78
<i>Hyla lanciformis</i>	DUELLMAN 78
<i>Hyla minuta</i>	* BOKERMANN 63; VIZZOTTO 76; KENNY 69; DUELLMAN 78
<i>Hyla cf. microcephala</i>	
<i>Hyla cf. nana</i>	* BOKERMANN 63; CEI 80
<i>Hyla cf. parviceps</i>	* DUELLMAN & CRUMP 74; DUELLMAN 78
<i>Hyla sp. 1</i>	*
<i>Ololygon cruentomma</i>	DUELLMAN 78
<i>Ololygon garbei</i>	DUELLMAN 78
<i>Ololygon cf. rubra</i>	* KENNY 69; DUELLMAN 78
<i>Osteocephalus buckleyi</i>	*
<i>Osteocephalus taurinus</i>	* DUELLMAN 78
<i>Osteocephalus sp.</i>	*
<i>Phrynohyas coriaceae</i>	

Table 2: Continuation

Species		Published descriptions
HYLIDAE		
<i>Phrynohyas resinifictrix</i>	*	McDIARMID et al. (Ms)
<i>Phyllomedusa bicolor</i>	*	
<i>Phyllomedusa tarsius</i>	*	DUELLMAN 78
<i>Phyllomedusa tomopterna</i>	*	LESCURE 75; DUELLMAN 78
<i>Phyllomedusa vaillanti</i>	*	DUELLMAN 78; CARAMASCHI & JIM 83
LEPTODACTYLIDAE		
<i>Adenomera andreae</i>	TD*	HEYER & SILVERSTONE 69
<i>Ceratophrys cornuta</i>	*	DUELLMAN 78
<i>Eleutherodactylus fenestratus</i>	DD	This study
<i>Eleutherodactylus</i> sp. 1	DD	This study
<i>Eleutherodactylus</i> sp. 2	DD	This study
<i>Leptodactylus fuscus/longirostris</i>	*	CROMBIE & HEYER 83; LESCURE 72
<i>Leptodactylus knudseni</i>	*	
<i>Leptodactylus mystaceus</i>	*	DUELLMAN 78
<i>Leptodactylus</i> cf. <i>ocellatus</i>	*	CEI 80 (may not be conspecific)
<i>Leptodactylus pentadactylus</i>	TD*	BREDER 46; KENNY 69; DUELLMAN 78
<i>Leptodactylus rhodomystax</i>	*	DUELLMAN 78
<i>Leptodactylus riveroi</i>		
<i>Leptodactylus stenodema</i>	TD	HOOGMOED pers. comm.
<i>Leptodactylus wagneri/podicipinus</i>	*	DUELLMAN 78
<i>Lithodytes lineatus</i>		REGÖS & SCHLÜTER 84
<i>Odontophrynus/Proceratophrys</i> sp.	*	
MICROHYLIDAE		
<i>Chiasmocleis</i> cf. <i>shudikarensis</i> or <i>C. cf. ventrimaculata</i>	*	
<i>Ctenophryne geayi</i>		
<i>Elachistocleis ovalis</i>		KENNY 69; CEI 80
<i>Synapturanus mirandaribeiroi</i> or <i>Synapturanus salseri</i>	TD*	PYBURN 75
PIPIDAE		
<i>Pipa pipa</i>	DD	
<i>Pipa arrabali</i>	DD	

Community Ecology

Species diversity

In central Amazonia 54 species of frogs have been found in association with rain-forest and an additional 11 species have been recorded in association with floating meadows (HÖDL 1977) for a total of 65 species. Additional studies are necessary in order to properly sample the neglected open areas and the Igapó or flooded forest where several additional

species are known to occur. The species richness of the central Amazon compares well with the diversity of the amphibia in other parts of the Amazon where 87 species were recorded in Santa Cecilia, Ecuador (CRUMP 1974; DUELLMAN 1978) and 71 species in Panguana, Peru (AICHINGER 1987).

Reproductive modes

As found in previous studies in the tropics, a great variety of reproductive modes is present in central Amazonas (Table 1). Reproductive mode was determined for 42 of the total of 54 species (Table 1). Direct development with no free-living tadpole stage is found in five species (12 %), eggs of these species generally are laid in the soil or leaf litter, however in two species of the genus *Pipa*, eggs are carried on the females back. Six species (14 %) have terrestrial development within an isolated burrow or nest and the tadpoles are thought to be non-feeding (*Colostethus* sp., *Adenomera andreae*, *Leptodactylus stenodema*, *L. pentadactylus*, and *Synapturanus* sp.). Terrestrial, or arboreal oviposition followed by aquatic tadpole development occurs in 13 species (31 %), in a wide range of genera (*Centrolenella*, *Dendrophryniscus*, *Colostethus*, *Epipedobates*, *Phyllomedusa* and *Leptodactylus*). Of the remaining 18 species (43 %) that have normal aquatic egg and tadpole development, three species still isolate their egg clutches from normal oviposition sites (ponds and streams): *Phrynohyas resinifictrix* uses arboreal tree hollows, *Osteocephalus* sp. oviposits in leaf axils in arboreal plants (primarily bromeliads), and *L. ocellatus* lays its eggs in a foam nest that floats on the water surface and the eggs and tadpoles are guarded by the female parent.

Of particular interest is the reproductive behaviour of the genus *Leptodactylus*. It has been well documented in previous studies that these species lay eggs in foam nests that generally are placed beside a pond or stream (with the exception of *L. cf. ocellatus* which puts its foam nests directly on the water surface; HEYER 1969). Eggs develop in the nest, and tadpoles swim into the pond or stream with rains. Occasionally nests are inundated by flooding ponds, however this follows oviposition. Therefore, I consider this reproductive mode to be terrestrial oviposition followed by aquatic tadpole development (Table 2).

Two species of anuran were found to reproduce in arboreal waterbodies, *Phrynohyas resinifictrix* and *Osteocephalus* sp. Within the RFAD, *Osteocephalus* sp. were heard calling from arboreal bromeliads and tadpoles were commonly encountered within the leaf axils throughout the wet season. Most tadpoles encountered had anuran eggs, presumably of the same species, in their digestive tracts. As in many species where tadpole development is confined to small arboreal waterbodies, egg cannibalism is probably common in this species (CRUMP 1983; LANNOO et al. 1987). The *Osteocephalus* sp. tadpole does not fit any of the classifications proposed by LANNOO et al. (1987) however approximates group 2 being oophagous and with a tail/body ratio of 1.7, and approaches group 3 with a dental formula of 2/3.

Tadpole habitat

The distribution of tadpoles among habitats suggests that species select specific sites for reproduction (Table 1). Few species occurred in more than one habitat (stream, stream-side pond or isolated forest pond) and there is low overlap between the isolated and stream-

side ponds. This is in general agreement with the local distributions of calling frogs and tadpoles throughout the tropics (CRUMP 1971, 1974; HEYER 1973, 1976; INGER et al. 1986; AICHINGER 1987; ZIMMERMAN & RODRIGUES 1990; CARDOSO et al. 1989). The selective forces acting on tadpole community structure were also investigated and will be published separately.

Tadpole microhabitat

Partitioning of pond microhabitat among tadpole species is evident with approximately half of the species in each habitat feeding in the leaf litter and half in the water column (Table 1). HEYER (1973) observed a similar spatial segregation of living space among tadpole species in a seasonal tropical location in Thailand. The ecological implications of spatial segregation rather than selecting different food categories is unclear (HEYER 1973). Feeding disturbance by other tadpole species may be an important factor in explaining spatial segregation of species (RICHMOND 1947; STEINWASCHER 1978; ODENDAAL et al. 1984).

Tadpole seasonality

The temporal distribution of tadpoles and calling males is presented in table 3. Despite the distinct wet and dry seasons in this area, tadpoles of many species (*C. oyampiensis*, *C. marchesianus*, *E. femoralis*, *H. geographica*, *O. taurinus*, *P. bicolor*, *P. tarsius*, *P. tomopterna*, *P. vaillanti* and *L. knudseni*) can be encountered all year round. Several species are predominantly found in the wet season (*D. minutus*, *H. cf. nana*, *O. sp.*, *A. andreae*, *E. fenestratus*, *L. mystaceus*, *L. pentadactylus*, *L. rhodomystax* and *C. cf. ventrimaculata*) and breed in isolated foam nests or ponds which may dry up completely at the end of the dry season. Two species (*H. boans* and *O. buckleyi*), predominantly found in the dry season, are only known to breed in the streams which are unstable during the wet season due to periodic flooding. The greatest number of species are present as larvae, at the beginning and at the end of the wet season (October/November and March/April respectively, Table 3). These results are similar to those encountered in a comparative study by HEYER (1973) in Sakaerat, Thailand. These peaks may be due to the overlap of wet and dry season species or a surge of reproduction from gravid females in these periods. Preliminary data for three species of *Phyllomedusa* in the RFAD suggests the latter, however the ecological implications of this behaviour are unclear. Females may be responding to environmental cues that ensure, 1) that long-lived tadpoles have an entire wet season to develop to metamorphosis, and/or 2) that eggs laid late in the season have enough time to reach metamorphosis before the ponds dry out. Alternatively, females may be returning at the end of the wet season with a second clutch.

Of particular note is the lack of seasonality among tadpole species (Table 3). This does not preclude temporal segregation of tadpole species as species do not always overlap spatially. Most tadpoles can be found throughout the year when ponds contain water. While the area has seasonal rainfall, all ponds studied contained water continuously for at least 8 months of the year (November - July). Only the stream-dwelling species reproduce predominantly in the dry season presumably due to high mortality of eggs and larvae from the sporadic flooding in the wet season.

Table 3: Tadpole seasonality; summary of calling patterns and tadpole occurrence. X = eggs and/or tadpoles collected; C = calling male only * signifies casual observations and/or collections suggesting that the species could be found in months other than those indicated.

Month	J	F	M	A	M	J	J	A	S	O	N	D
BUFONIDAE												
* <i>Bufo granulosus</i>			X --	X				C		X		
* <i>Bufo marinus</i>							X --	X --	X			
* <i>Bufo cf. typhoni</i>	X --	X --	X								X --	X
<i>Dendrophryniscus minutus</i>	X --	X --	X --	X --	X --	X --	X --	X		C	C	X
CENTROLENIDAE												
<i>Centrolenella oyampiensis</i>	X --	X --	X --	X --	X --	X --	X --	X --	X --	X --	X --	X
DENDROBATIDAE												
<i>Colostethus marchesianus</i>	X --	X --	X --	X --	X --	X --	X --	X --	X --	X --	X --	X
<i>Epipedobates femoralis</i>	X --	X --	X --	X --	X --	X	C	X --	X --	X --	X --	X
HYLIDAE												
<i>Hyla boans</i>	X		X		X	C	X --	X --	X --	X --	X --	X
<i>Hyla geographica</i>	X --	X --	X --	X --	X --	X --	X --	X --	X --	X --	X --	X
* <i>Hyla granosa</i>	X	C	C	C	C	X	C	C	X --	X --	X --	X
* <i>Hyla minuta</i>			C	X		X						
<i>Hyla cf. nana</i>	X --	X --	X --	X		X						
* <i>Hyla cf. parviceps</i>					X							
* <i>Hyla sp. 1</i>				X								
* <i>Ollolygon cf. rubra</i>			X --	X						X --	X	
<i>Osteocephalus buckleyi</i>			X		X --	X --	X		X --	X --	X	
<i>Osteocephalus taurinus</i>	X --	X --	X --	X --	X --	X --	X --	X --	X --	X --	X --	X
<i>Osteocephalus sp.</i>	C	C	X --	X	C	C	C	C	X --	X --	X --	X
* <i>Phrynohyas resinifictrix</i>			X									
<i>Phyllomedusa bicolor</i>	X --	X --	X --	X --	X --	X --	X --	X	C	X --	X --	X
<i>Phyllomedusa tarsius</i>	X --	X --	X --	X --	X --	X --	X --	X --	X --	X --	X --	X
<i>Phyllomedusa tomopterna</i>	X --	X --	X --	X --	X --	X --	X --	X --	X --	X --	X --	X
<i>Phyllomedusa vaillanti</i>	X --	X --	X --	X --	X --	X --	X --	X --	X --	X --	X --	X
LEPTODACTYLIDAE												
* <i>Adenomera andreae</i>	C	C	C	C	C				C	C	X	C
* <i>Ceratophrys cornuta</i>			X		X					X		
* <i>Eleutherodactylus fenestratus</i>	C	C	C	C	C			C	C	C	X	C
* <i>Eleutherodactylus sp. 1</i>	C --	C								C	X	C
* <i>Eleutherodactylus sp. 2</i>		C								C	C	X
* <i>Leptodactylus fuscus/longirostris</i>	X											X
<i>Leptodactylus knudseni</i>	X --	X --	X --	X --	X --	X --	X --	X --	X --	X --	X --	X
* <i>Leptodactylus mystaceus</i>	X --	X --	X --	X								
* <i>Leptodactylus cf. ocellatus</i>							X					
<i>Leptodactylus pentadactylus</i>										C	X --	X --
<i>Leptodactylus rhodomystax</i>	X --	X --	X --	X --	X			C	C	X --	X --	X

Table 3: Continuation

Month	J	F	M	A	M	J	J	A	S	O	N	D
* <i>Leptodactylus riveroi</i>	C		C	C	C	C	C			C	C	C
* <i>Leptodactylus wagneri/podicipinus</i>				C	C	X --	X					
* <i>Leptodactylus stenodema</i>			C	C	C	C	C	C	C	C		C
* <i>Odontophrynus/Proceratophrys</i> sp.	X											
MICROHYLIDAE												
* <i>Chiasmocleis</i> cf. <i>shudikarensis</i>				X --	X --	X				X		
<i>Chiasmocleis</i> cf. <i>ventrimaculata</i>	X	C	X --	X						X --	X --	X
* <i>Synapturanus mirandaribeiroi</i> or <i>Synapturanus salseri</i>	C	C	C	C	C	C	C	C	C	C	X	C
Total no. of species	26	23	30	28	25	22	21	19	21	29	26	25

Summary

The seasonal tropical rainforest of the central Amazon demonstrates a great richness of species and reproductive modes. The tadpole community shows high habitat specificity within and among waterbodies. The lack of seasonality exhibited by tadpole species may be a reflection on the availability of waterbodies for at least 8 months of the year. Competition among tadpole species is minimized by spatial segregation among waterbodies, and temporal and microhabitat segregation of tadpole species within waterbodies. The temporal and spatial partitioning of the tadpole species in central Amazonia are similar to studies on tadpole communities in Thailand (HEYER 1973), Ecuador (CRUMP 1974), Panama and Maryland (HEYER 1976), and Borneo (INGER et al. 1986). These studies suggest that competition among tadpole species is minimized. Microhabitat partitioning and, the high number of reproductive modes and breeding sites utilized by tropical anurans probably facilitate the coexistence of many species (CRUMP 1971, 1974; DUELLMAN 1978; this study).

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Glossary (Modified from ALTIG 1970)

BODY LENGTH: see Fig. 3. (= head-body length).

DENTICLES: see "Labial Teeth".

DEXTRAL: pertaining to or on the right hand side.

FIN: membranous flap along the dorsal and ventral margins of the caudal musculature.

FLAGELLUM: an attenuate posterior portion of the tail capable of undulating independently of the remainder of the tail.

JAW: (= beak), usually with heavily keratinized sheaths.

LABIAL FLAP: membranous flap suspended in front of the mouth of some tadpoles.

LABIAL TEETH: keratinized structures occurring in transverse rows on each labium (= denticles).

LABIAL TOOTH ROW FORMULA (LTRF): a formula designating the number and position of rows of labial teeth; the numerator indicates the number of rows on the anterior (A) labium, and the denominator indicates the rows on the posterior (P) labium. Letter abbreviations and row numbers (e. g. A-1, P-3) are explained in Figure 4. Rows with median gaps are in parentheses. A range in the number of rows is hyphenated and variability in the presence of a median gap is indicated by brackets []. For example, the formula 2 (2) / 3-4 [1] indicates two rows on the anterior labium, the second with a median gap, and three or four rows on the posterior labium, the first with or without a median gap. The labial tooth formula for the tadpole in Figure 4 is 2 (2) / 3.

LABIUM: Half of oral disc (see fig. 2), anterior (AL), posterior (PL), usually supporting labial teeth and papillae.

MARGINAL PAPIILLAE: papillae attached to the margin of the oral disk.

MEDIOVENTRAL: pertaining to or located at the midpoint on the ventral surface.

ORAL DISK: collective term for combination of anterior and posterior labia supporting labial teeth and papillae. May be terminal, dorsal, anteroventral or ventral.

PAPILLARY BORDER: collective term for marginal papillae surrounding the oral disc. May be with or without dorsal or ventral gaps.

PARAGYRINID: located well below the horizontal longitudinal axis but not on the midline so neither sinistral nor medioventral are entirely applicable (eg. *Phyllomedusa*).

SINISTRAL: pertaining to or located on the left side.

SPIRACLE: external opening of the opercular chamber for the exit of respiratory water.

SUBMARGINAL PAPIILLAE: papillae attached to the oral disc apart from the margin and marginal papillae.

TOTAL LENGTH (TL): Distance from the tip of the snout to the tip of the tail (see Fig. 3).

VENT TUBE: external tube leading from the cloacal aperture.

VENTER: the lower or ventral surface of the tadpole body.

Key to tadpoles of central Amazônia

1.	Oral disc, jaws and labial teeth absent	2
	Oral disc, jaws and/or labial teeth present	4
2.	Mouth ventral, terrestrial (direct development)	
	<i>Synapturanus</i> sp.	
	Mouth terminal, aquatic	3
3.	Body pigmentation continuous with clear spots	<i>Chiasmocleis</i> cf. <i>ventrimaculata</i>
	Body clear with large spots of dark pigmentation	<i>Chiasmocleis</i> cf. <i>shudikarensis</i>
4.	Jaws present labial teeth absent	5
	Jaws and labial teeth present	8
5.	Eyes dorsolateral, vent tube medial, in terrestrial foam nest	<i>Adenomera andreae</i>
	Eyes lateral, vent tube dextral	6
6.	Posterior papillae absent	<i>Hyla</i> cf. <i>nana</i>
	Posterior papillae present	7
7.	Body dark brown	<i>Hyla</i> cf. <i>parviceps</i>
	Body transparent	<i>Hyla</i> sp. 1
8.	LTF 6-9/6-9, distinct medial serration on the lower jaw	<i>Ceratophrys cornuta</i>
	Not as above	9
9.	Green at hatching and thereafter, skin transparent and appears red from blood; eyes dorsal, body and tail extremely elongate, LTRF 0/1-2	<i>Centrolenella oyampiensis</i>
	Not as above	10
10.	Papillary border with a ventral gap slightly less than, equal to, or larger than P3	11
	Papillary border without ventral gap or, if present, only one or two papilla wide (eg. <i>Hyla granosa</i>)	14
11.	Labial tooth gaps absent, LTRF 2/3	<i>Dendrophryniscus minutus</i>
	Labial tooth gaps present, LTRF 2(2)/3(1)	12
12.	Body and tail musculature with sparse small black spots	<i>Bufo</i> cf. <i>typhonius</i>
	Body and tail musculature uniform black	13
13.	Venter clear, intestine clearly visible	<i>Bufo granulosus</i>
	Venter dark, intestine not or barely visible	<i>Bufo marinus</i>
14.	Vent tube dextral	15
	Vent tube medial	28
15.	Eyes lateral	16
	Eyes dorsal or dorsolateral	21
16.	Spiracle sinistral	17
	Spiracle paragyrid	18
17.	LTRF 0/2	<i>Hyla minuta</i>
	LTRF 2(2)/3[1]	<i>Oloolygon rubra</i>
18.	Glandular mass along the dorsal edge of upper tail fin; entire body and tail orange	19
	Not as above	20.
19.	Distinct clump of melanophores between eyes	<i>Phyllomedusa vaillanti</i>
	Not as above	<i>Phyllomedusa bicolor</i>
20.	In life, lower tail fin with orange patch (characteristic possibly lost in large individuals in some habitats)	<i>Phyllomedusa tomopterna</i>
	Lower tail fin without orange patch	<i>Phyllomedusa tarsius</i>

21.	Lateral papillae overlap < 10 % of AI	22
	Lateral papillae overlap > 30 % of AI	23
22.	Distinct band of melanophores across the venter, maximum TL 33.2 mm, stage 40	<i>Epipedobates femoralis</i>
	Few scattered melanophores across the venter, maximum TL 20.4 mm, stage 39	<i>Colostethus marchesianus</i>
23.	Body and tail uniform black	<i>Hyla geographica</i>
	Not as above	24
24.	Single pointed papilla on external naris, labial tooth row formula 2(1,2)/3-4(1) [2], ventral papillary border with slight medial gap	<i>Hyla granosa</i>
	Without papilla on external naris	25
25.	Labial tooth row formula 2(2)/3-4(1), tail muscle with distinct dark dorsal blotches	<i>Hyla boans</i>
	Not as above	26
26.	Body dark blue with a partially clear medial band, only in streams	<i>Osteocephalus buckleyi</i>
	Not as above	27
27.	Labial tooth row formula 2(2)/3[1], in bromeliads and arboreal water bodies	<i>Osteocephalus</i> sp.
	Labial tooth formula 2(2)/3-7(1)	<i>Osteocephalus taurinus</i>
28.	Only in large treeholes	<i>Phrynohyas resinifictrix</i>
	In ponds or streams	29
29.	Intestine in transverse rows	<i>Proceratophrys/Odontophrynus</i> sp.
	Intestine coiled centrally	30
30.	Mouth with only a single anterior row of labial teeth, in terrestrial burrows	<i>Leptodactylus pentadactylus</i>
	Mouth with two anterior rows of labial teeth	31
31.	Tooth row P1 continuous, LTRF 2[2]/3, body and tail uniformly spotted	32
	Tooth row P1 interrupted medially, LTRF 2[2]/3(1), melanophores in irregular clumps along the tail	34
32.	Tooth row A2 continuous, LTRF 2/3	<i>Leptodactylus ocellatus</i>
	Tooth row A2 interrupted medially, LTRF 2(2)/3	33
33.	Tooth row A2 gap distinct (approximately half the width of the upper jaw), body and tail uniform black	<i>Leptodactylus rhodomystax</i>
	Tooth row A2 gap slight, body black, tail black becoming transparent towards the tip	<i>Leptodactylus wagneri/podicipinus</i>
34.	Total size small (Gosner stage 26 < 25 mm)	<i>Leptodactylus fuscus</i>
	Total size large (Gosner stage 26 >> 25 mm)	35
35.	Body olive green, A2 gap slight	<i>Leptodactylus mystaceus</i>
	Body grey, A2 gap wide (length of one section of A2 < the width of the A2 gap)	<i>Leptodactylus knudseni</i>

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Plates

The following 36 plates were drawn from single specimens that have been placed in the Museu Nacional, Rio de Janeiro, Brasil. Each plate includes the species name, the museum number, total length (TL), and stage of development (GOSNER 1960) for the drawn specimen, and a general labial tooth row formula (LTRF) taken from several additional specimens (museum numbers in Appendix 1). The drawings depict melanic patterns that persist in preserved specimens (10 % formalin). Below each plate are: brief, background colour descriptions that do not include the dark melanic pigmentation shown in the drawings; species oviposition site; habitats where tadpoles were collected; months of the year that tadpoles were found; and the maximum total length of tadpole collected and its GOSNER (1960) stage. Plates (1 - 36) of drawn tadpoles are ordered alphabetically by family, genus and species consecutively.

Bufo granulatus

MNRJ 7826

TL 11.5mm, Stage 29

LTRF 2 (2) / 3

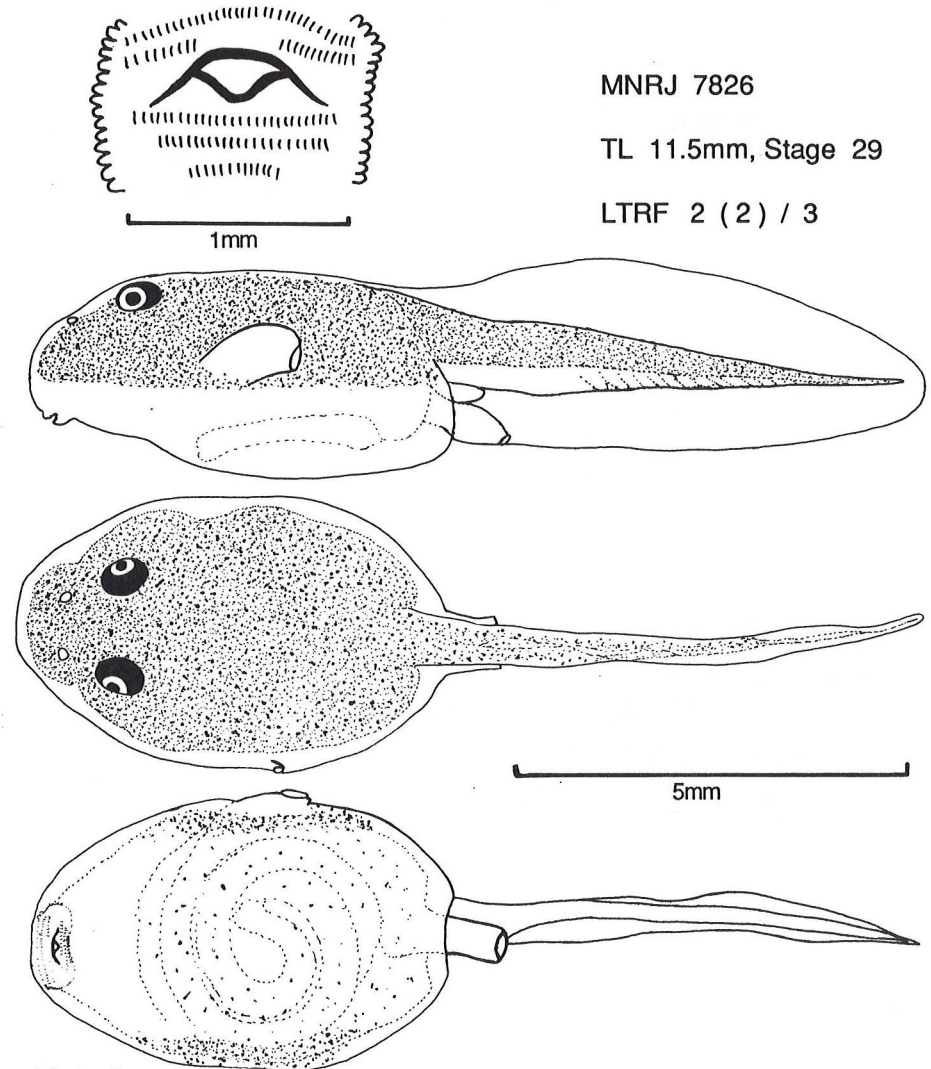


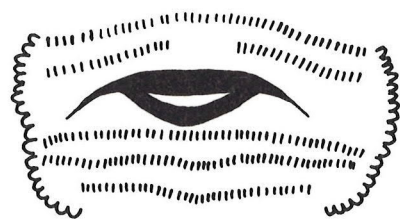
Plate 1

Body black above and transparent below; upper half of tail muscle black, fins transparent.

Eggs aquatic; Tadpole in ponds, lakes and streams of open and disturbed areas; March, April and October.

Max. TL 18.2mm, Stage 40.

Bufo marinus



MNRJ 7827

TL 29.1mm, Stage 41

LTRF 2 (2) / 3

1mm

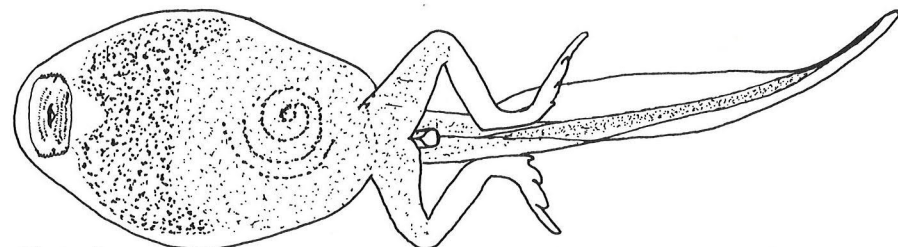
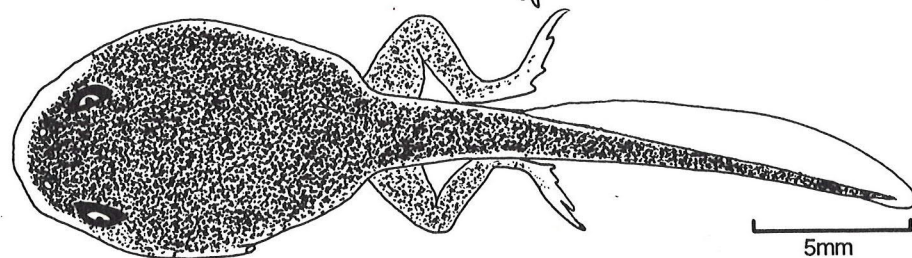
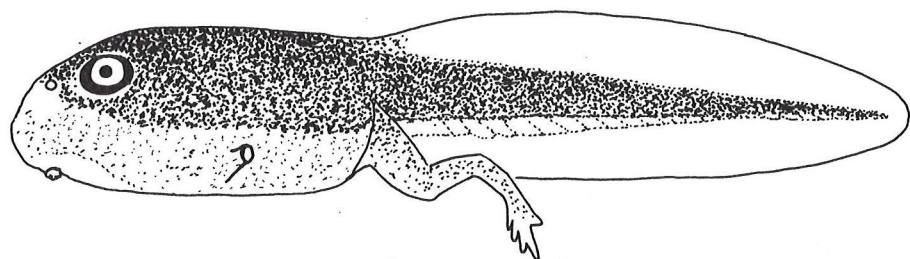


Plate 2

Body black above with scattered white chromatophores and black below with grey flecks; upper half of tail muscle black, lower half of tail muscle and fins transparent. Eggs aquatic; Tadpole in ponds, lakes and streams of open and disturbed areas; July - September.
Max. TL 29mm, Stage 41

Bufo cf. typhonius



MNRJ 7828

TL 12.9mm, Stage 36

LTRF 2 (2) / 3

1mm

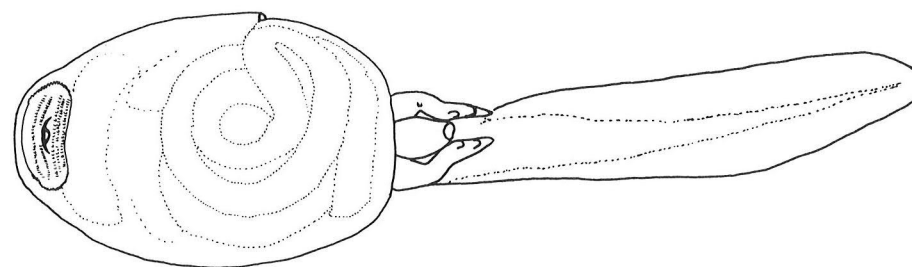
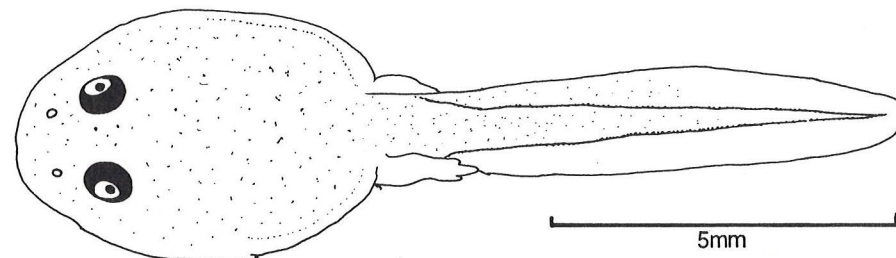
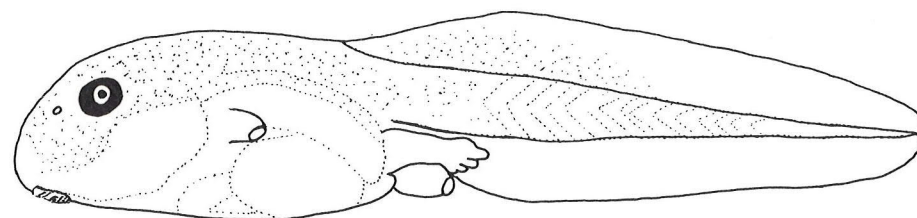
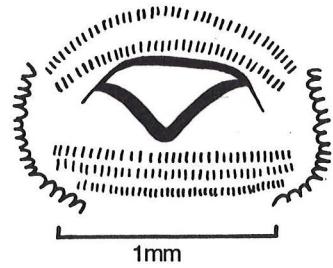


Plate 3

Body transparent olive brown; tail transparent. Eggs aquatic; Tadpole in streamside ponds; November - March.
Max. TL 12.9mm, Stage 36

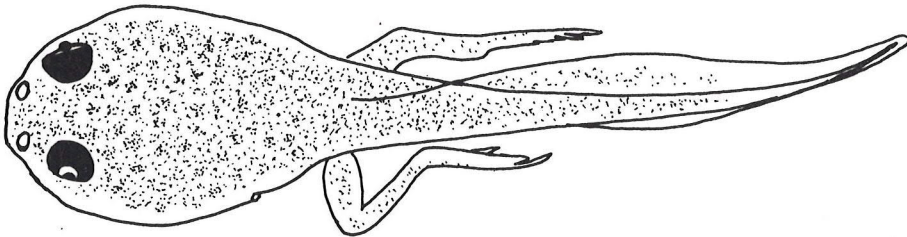
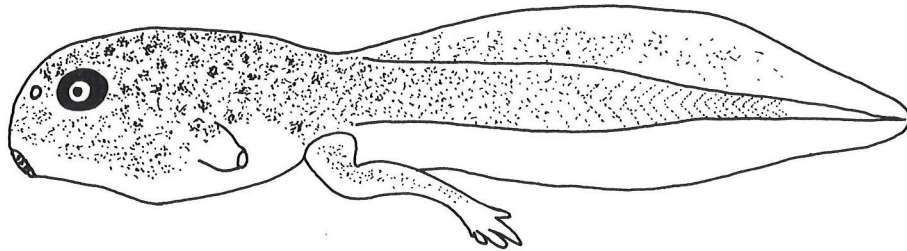
Dendrophryniscus minutus



MNRJ 7829

TL 16.0mm, Stage 41

LTRF 2 / 3



5mm

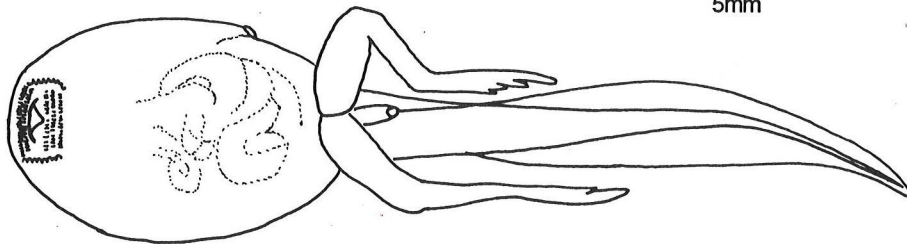
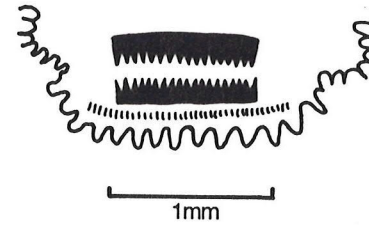


Plate 4

Body transparent light brown above and transparent below; tail transparent.
Eggs terrestrial; Tadpole in streamside ponds; December - August.
Max. TL 18mm, Stage 37

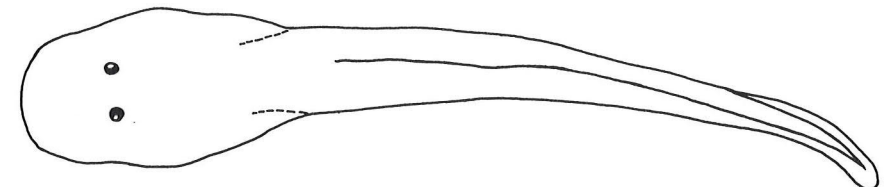
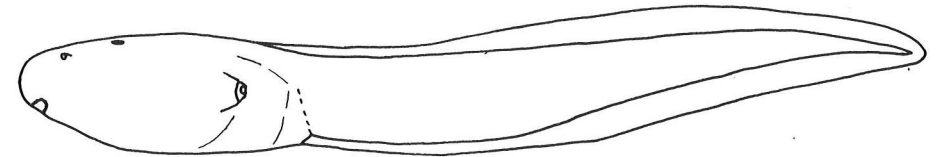
Centrolenella oyampiensis



MNRJ 7830

TL 25.3mm, Stage 25

LTRF 0 / 1 - 2



5mm

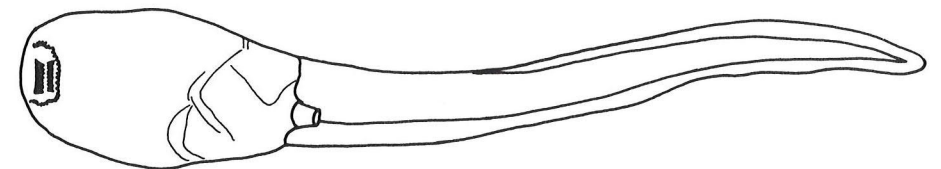
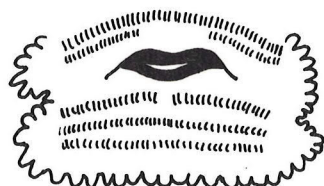


Plate 5

Body unpigmented but appears red from underlying blood vessels; tail transparent.
Eggs terrestrial/arboreal; Tadpole in streams; all months.
Max. TL 25.3, Stage 25

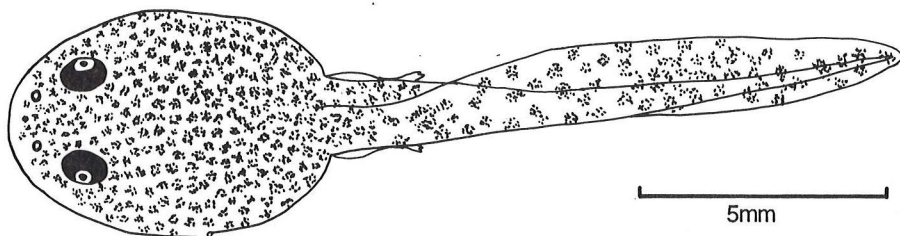
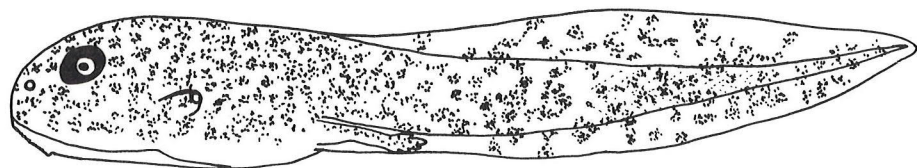
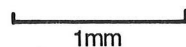
Colostethus marchesianus



MNRJ 7831

TL 18.3mm, Stage 38

LTRF 2 (2) / 3 (1)



5mm

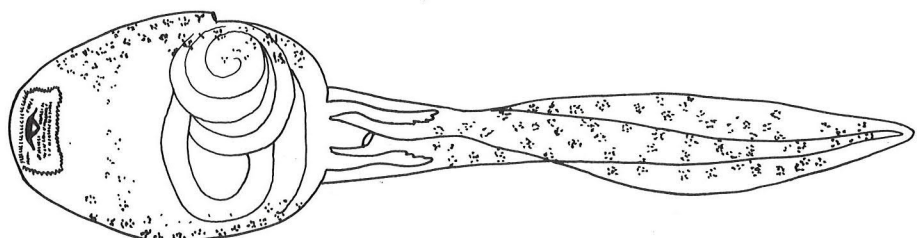


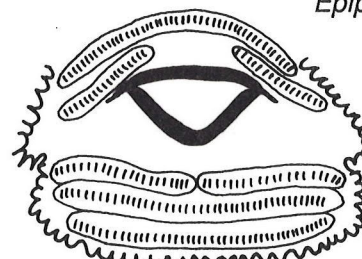
Plate 6

Body transparent brown with scattered white chromatophores and transparent abdomen; tail transparent brown.

Eggs terrestrial; Tadpole in streamside and isolated forest ponds; all months.

Max. TL 20.4mm, Stage 39

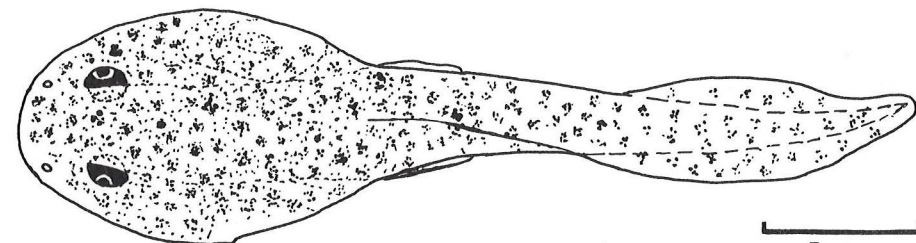
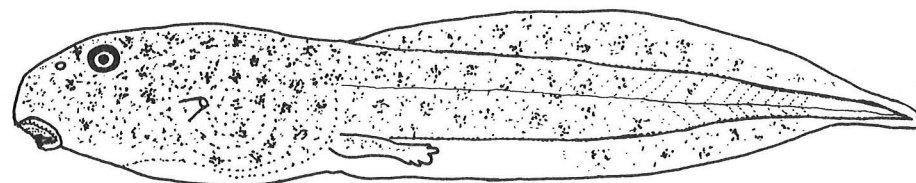
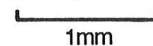
Epipedobates femoralis



MNRJ 7832

TL 28.6mm, Stage 37

LTRF 2 (2) / 3 (1)



5mm

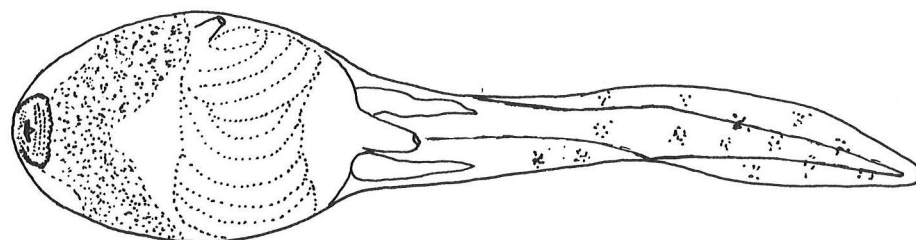


Plate 7

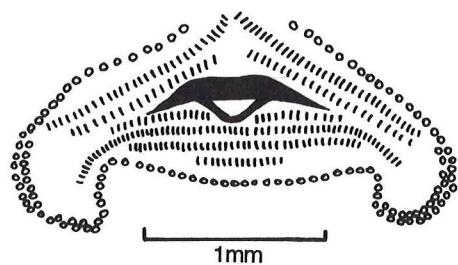
Body grey above with scattered white chromatophores and transparent abdomen; tail transparent.

Eggs terrestrial; Tadpole in isolated forest ponds;

August - June.

Max. TL 33.2mm, Stage 40

Hyla boans



MNRJ 7833

TL 30.7mm, Stage 34

LTRF 2 (2) / 3-4 (1)

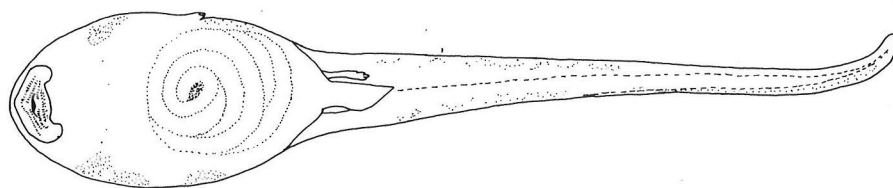
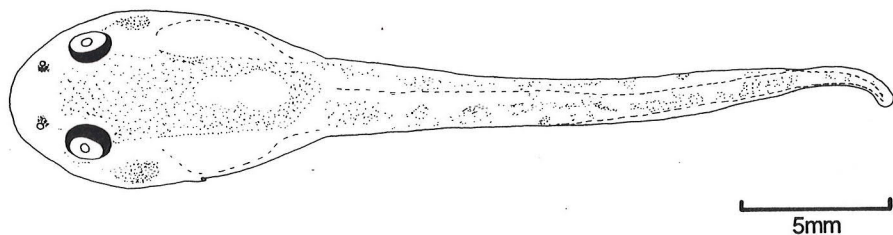
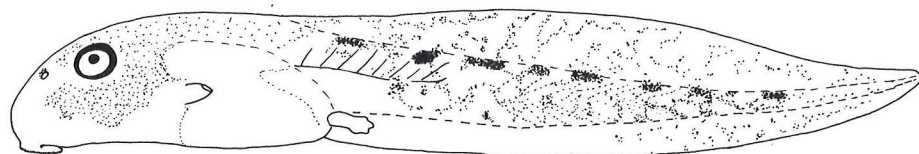


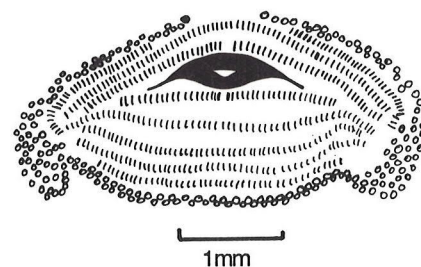
Plate 8

Body transparent olive brown; tail transparent.

Eggs aquatic; Tadpole in streams; July - January, March, May.

Max. TL 30.7mm, Stage 34

Hyla geographica



MNRJ 7834

TL 43.5mm, Stage 35

LTRF 2-3 [1] (3) / 3-5 [1]

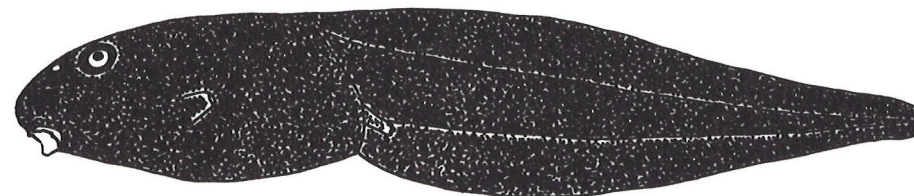


Plate 9

Body black; tail black.

Eggs aquatic; Tadpole in streamside ponds, lakes and occasionally streams; all months.

Max. TL 55.6mm, Stage 39

Hyla granosa

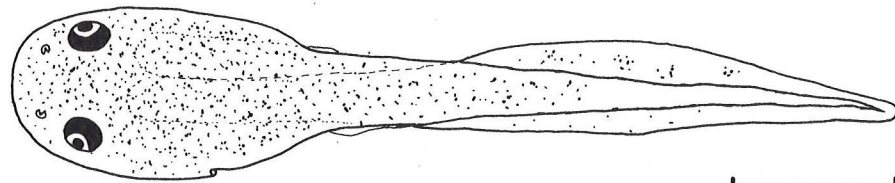
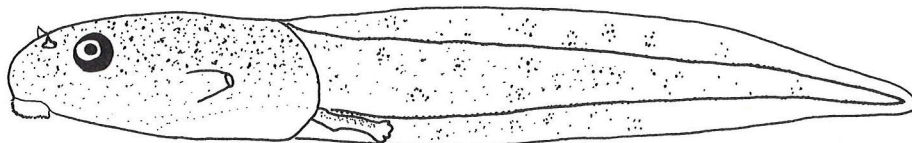


MNRJ 7835

TL 28.1mm, Stage 37

LTRF 2 (1,2) / 3-4 (1) [2]

1mm



5mm

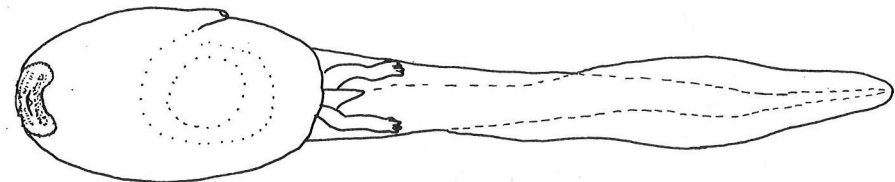


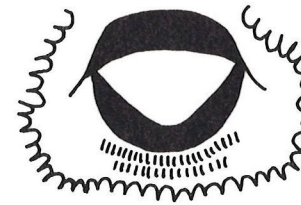
Plate 10

Body transparent olive brown with scattered white chromatophores; tail transparent with scattered white chromatophores.

Eggs aquatic; Tadpole in streams and streamside ponds; June, September - January.

Max. TL 29.8mm, Stage 34

Hyla minuta

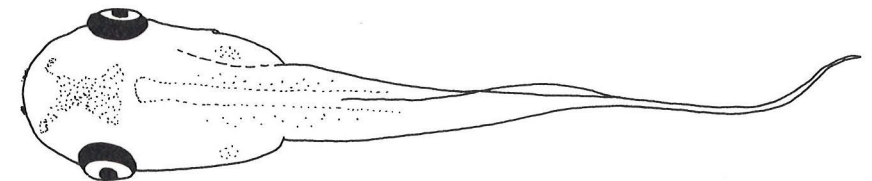
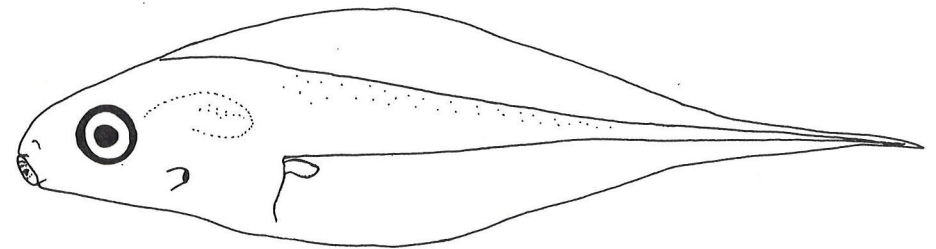


MNRJ 7850

TL 26.3mm, Stage 32

LTRF 0 / 1-2

1mm



5mm



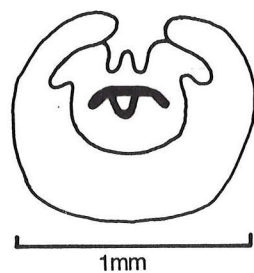
Plate 11

Body transparent with a silver abdomen; tail transparent.

Eggs aquatic; Tadpole in isolated ponds of open and disturbed areas; April, June.

Max. TL 28.1mm, Stage 37

Hyla cf. nana



MNRJ 7950

TL 16.7mm Stage 39

LTRF 0 / 0

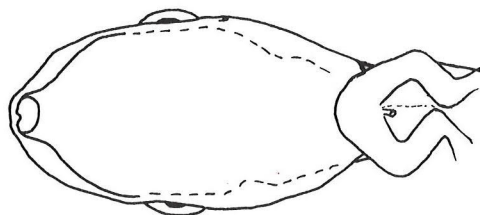
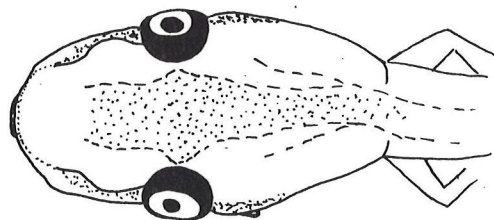
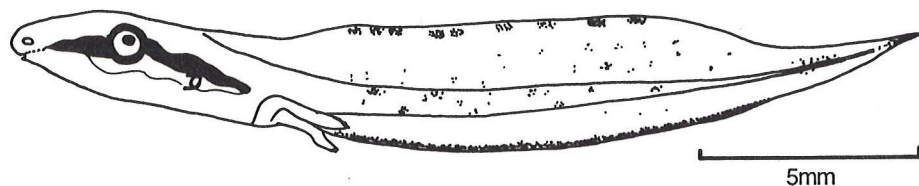


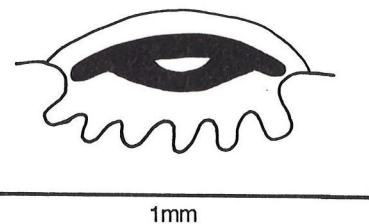
Plate 12

Body transparent orange with a black stripe through the eye; tail transparent orange.

Eggs aquatic ? ; Tadpole in streamside ponds; January - April, June.

Max. TL 20.5mm, Stage 40

Hyla cf. parviceps



MNRJ 7851

TL 8.4mm, Stage 25

LTRF 0 / 0

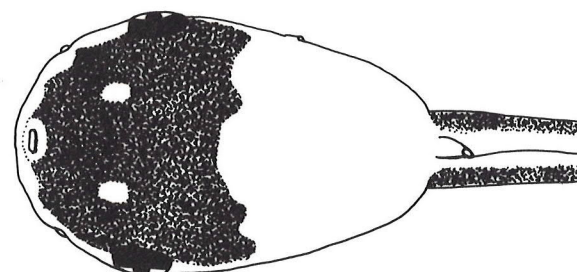
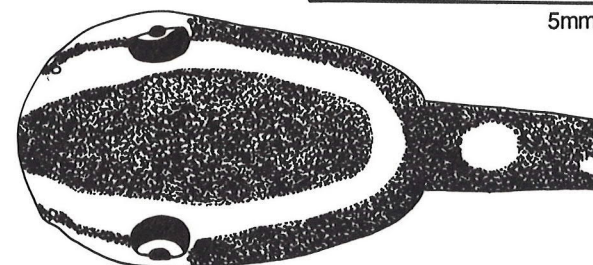
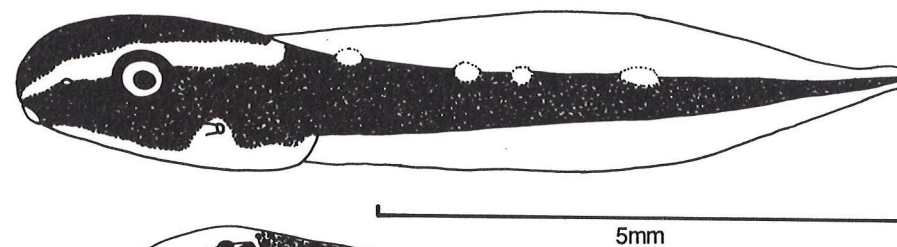


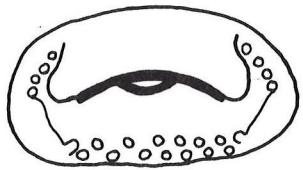
Plate 13

Body dark brown with a white band around the dorsal surface; tail muscle dark brown, fins transparent with white blotches.

Eggs unknown; Tadpole local, MCSEP reserve; May.

Max. TL 8.4mm, Stage 25

Hyla sp. 1

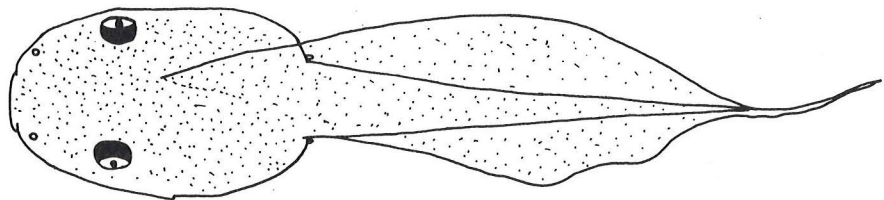
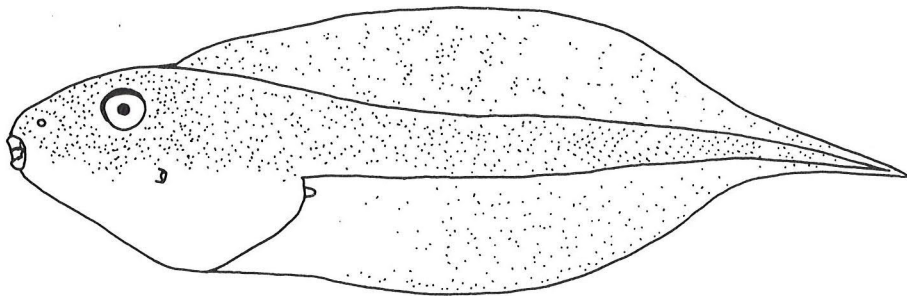


1mm

MNRJ 7951

TL 19.7mm, Stage 27

LTRF 0 / 0



5mm

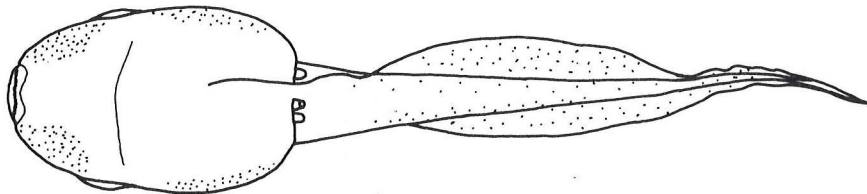
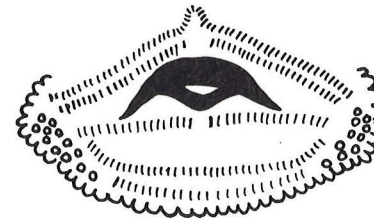


Plate 14

Body transparent; tail transparent.
Eggs aquatic ? ; Tadpole local, MCSEP reserve; April.
Max. TL 19.7mm, Stage 27

Ololygon cf. rubra

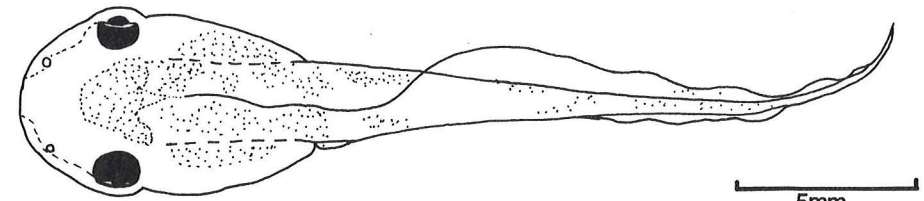
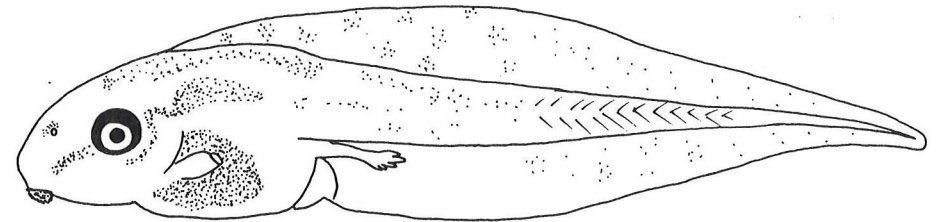


1mm

MNRJ 7852

TL 25.4mm, Stage 38

LTRF 2 (2) / 3 (1)



5mm

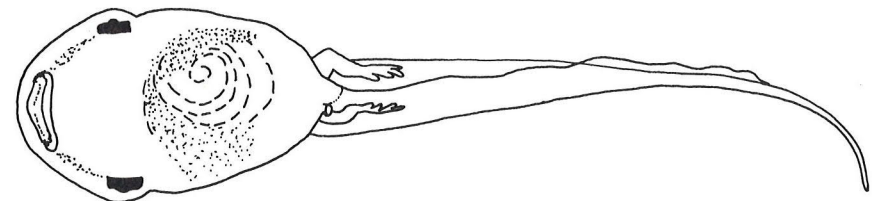
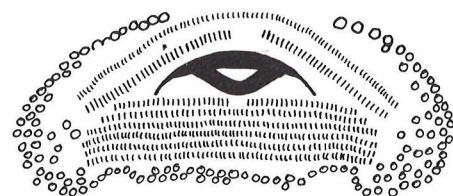


Plate 15

Body transparent with a silver abdomen; tail transparent.
Eggs aquatic; Tadpole in isolated ponds of open and disturbed areas; March,
April, October and November.
Max. TL 25.4mm, Stage 38

Osteocephalus buckleyi

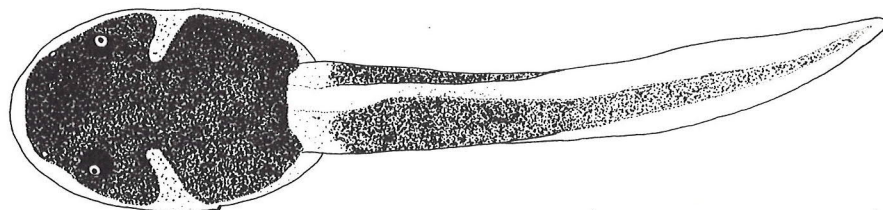
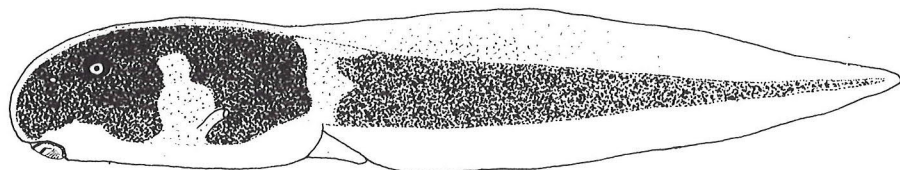


1mm

MNRJ 7837

TL 21.5mm, Stage 25

LTRF 2 (2) / 3-8 [1]



5mm

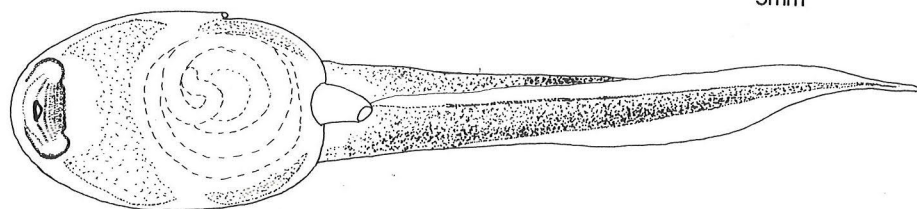


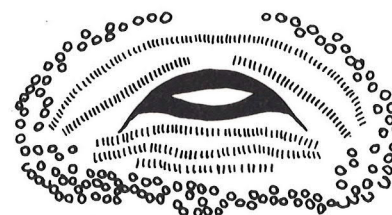
Plate 16

Body dark blue with a clear medial band and a transparent abdomen; tail muscle dark blue, fins transparent.

Eggs aquatic; Tadpole in streams; Eggs found in March, May - July and September - November.

Max. TL 36.3mm, Stage 38

Osteocephalus sp.

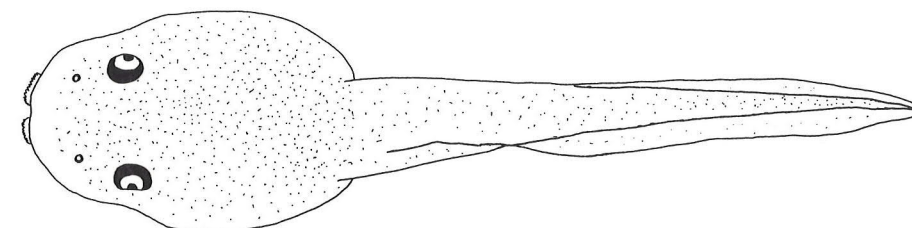
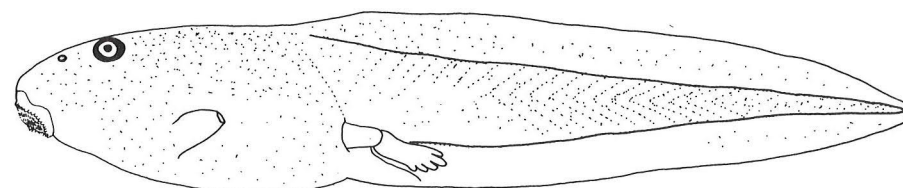


1mm

MNRJ 7836

TL 26.0mm, Stage 37

LTRF 2 (2) / 3 [1]



5mm

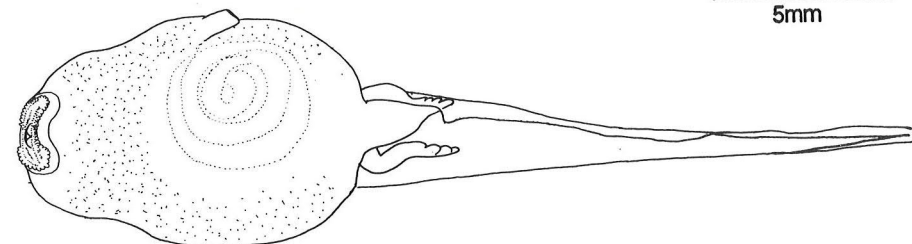


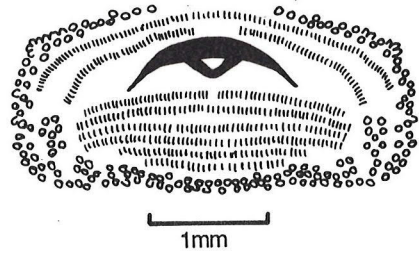
Plate 17

Body transparent olive with a band of white chromatophores between the eyes and the mouth; tail transparent.

Eggs aquatic; Tadpoles in bromeliads and arboreal waterbodies; March, April and September - December.

Max. TL 30.3mm, Stage 37

Osteocephalus taurinus



MNRJ 7838

TL 31.7mm, Stage 40

LTRF 2 (2) / 3-7 (1)

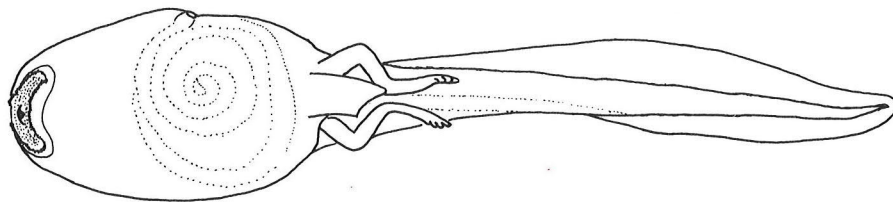
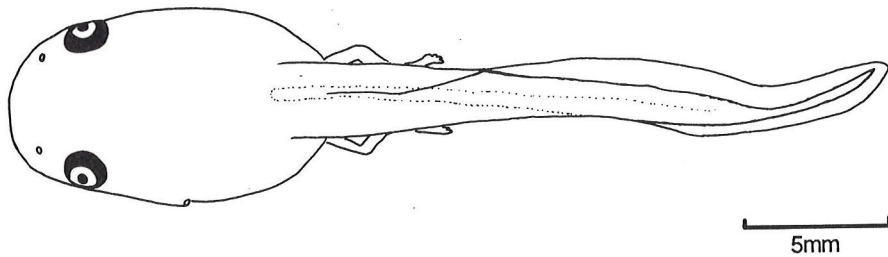
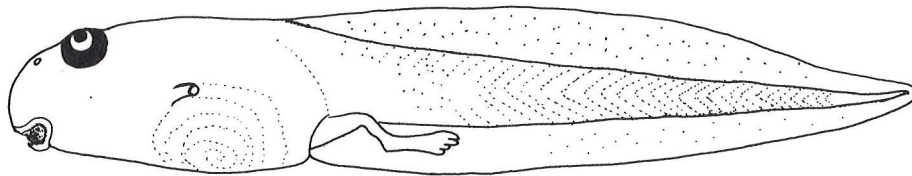
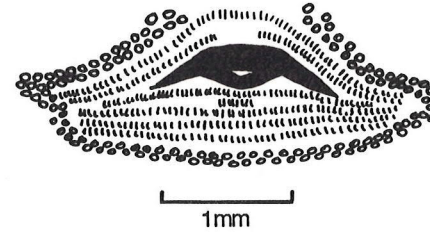


Plate 18

Body transparent olive with scattered white chromatophores; tail transparent.
Eggs aquatic; Tadpoles in isolated and streamside ponds; all months.
Max. TL 35mm, Stage 41

Phrynohyas resinifictrix



MNRJ 7848

TL 38.7mm, Stage 39

LTRF 2 (2) / 3-5

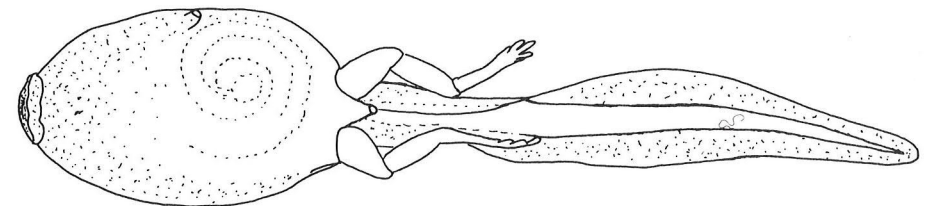
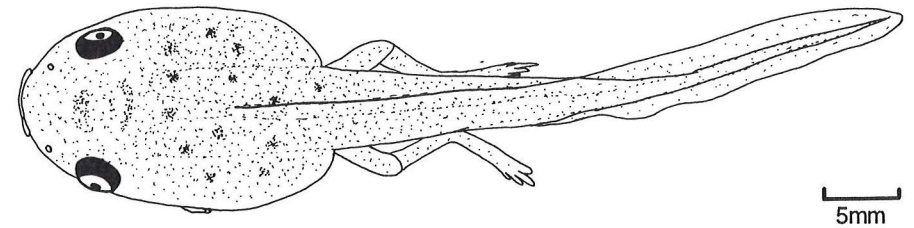
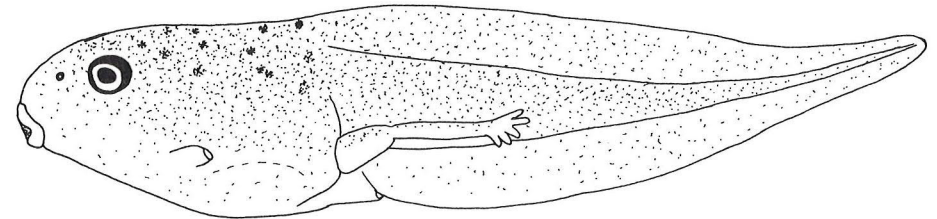
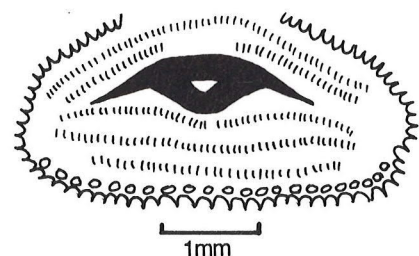


Plate 19

Body dark olive with a silver belly; tail transparent.
Eggs aquatic/arboreal; Tadpoles in treeholes; March.
Max. TL 38.7mm, Stage 39

Phyllomedusa bicolor



MNRJ 7853

TL 41.3mm, Stage 36

LTRF 2 (2) / 2-3 (1)

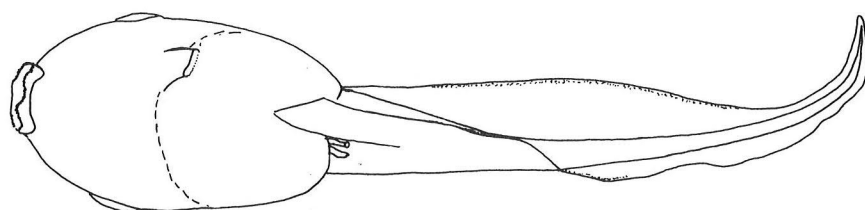
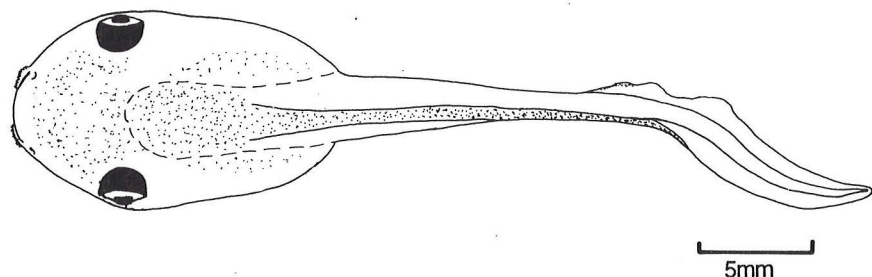
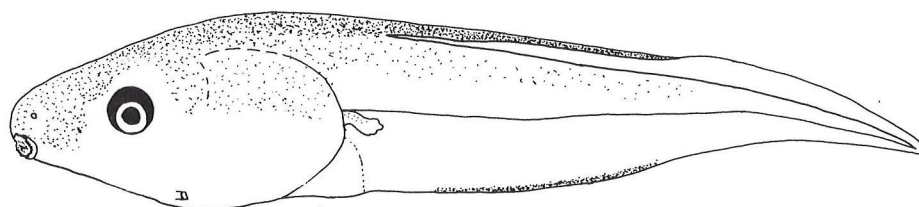
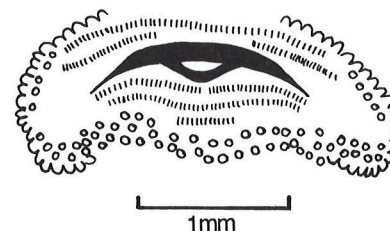


Plate 20

Body transparent orange with a silver belly; tail transparent orange.
Eggs terrestrial/arboreal; Tadpoles in isolated and streamside ponds;
October - August.
Max. TL 51.1mm, Stage 39

Phyllomedusa tarsius



MNRJ 7849

TL 35.6mm, Stage 31

LTRF 2 (2) / 2-3 [1]

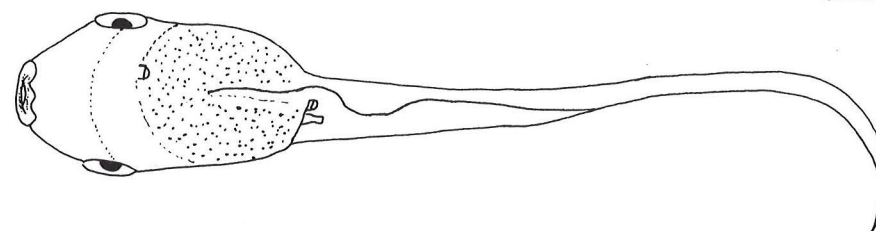
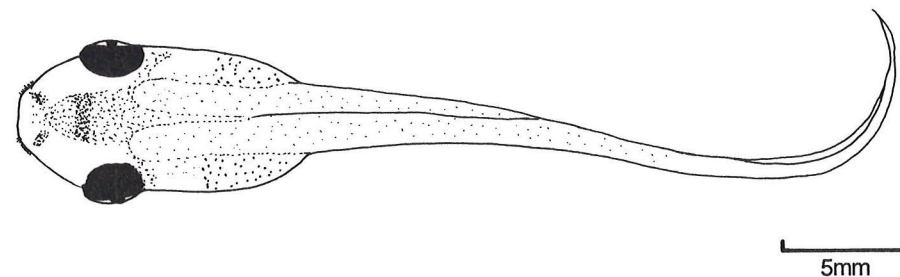
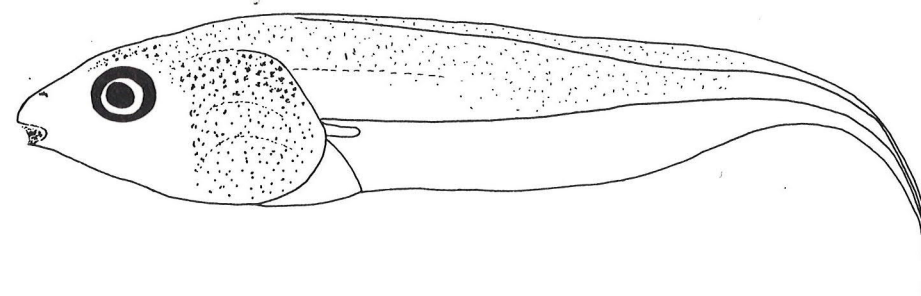
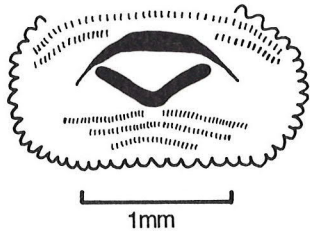


Plate 21

Body transparent olive or whitish with a silver belly; tail transparent or whitish.
Eggs terrestrial/arboreal; Tadpoles in isolated forest ponds; all months.
Max. TL 46.2mm, Stage 33

Phyllomedusa tomopterna



MNRJ 7854

TL 32.2mm, Stage 28

LTRF 2 (2) / 2-3 [1]

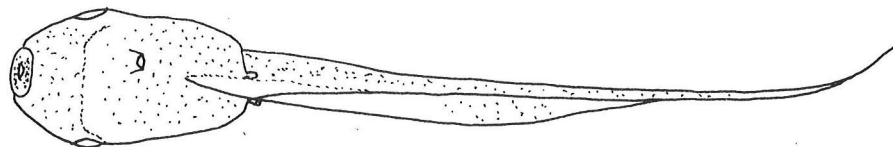
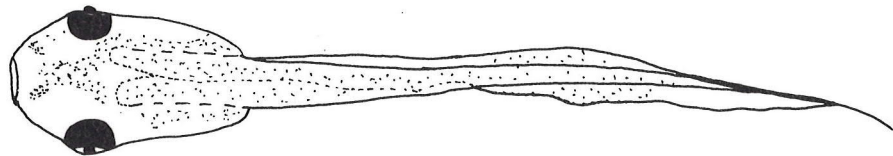
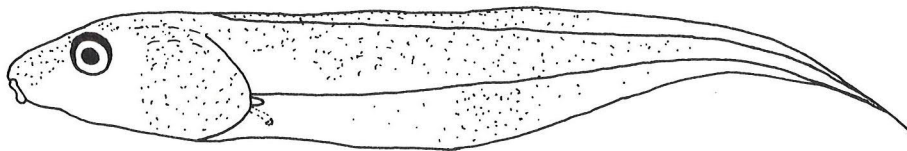


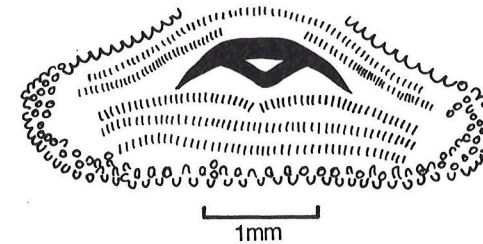
Plate 22

Body transparent olive or whitish with a silver abdomen; tail transparent or whitish with a diffuse orange patch midway along the lower fin.

Eggs terrestrial/arboreal; Tadpoles in isolated forest ponds; all months.

Max. TL 32.2mm, Stage 28

Phyllomedusa vaillanti



MNRJ 7839

TL 43.4mm, Stage 34

LTRF 2 [2] / 2-3 [1]

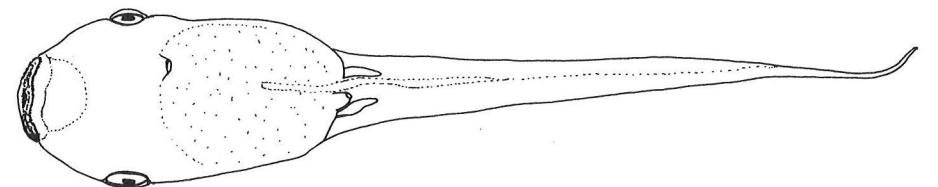
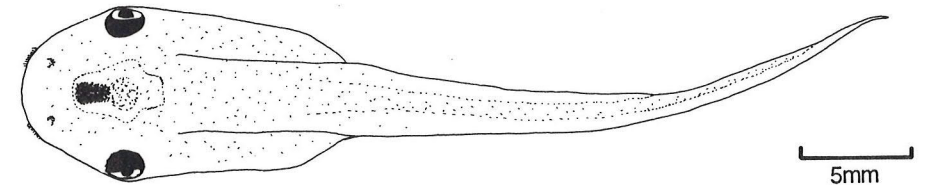
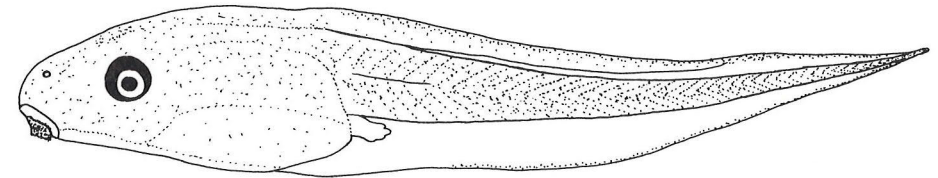


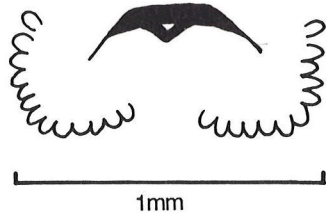
Plate 23

Body transparent orange with a silver abdomen; tail transparent orange.

Eggs terrestrial/arboreal; Tadpoles in streamside ponds; all months.

Max. TL 57.0mm, Stage 40

Adenomera andreae



MNRJ 7952

TL 13.6mm, Stage 39

LTRF 0 / 0

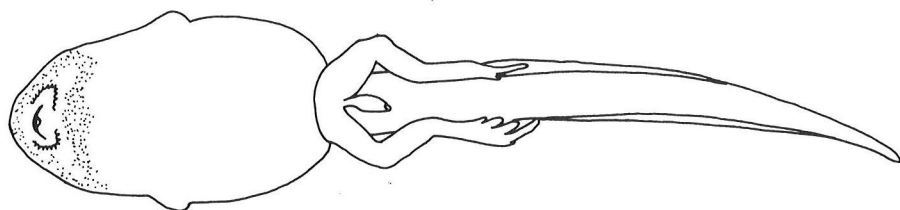
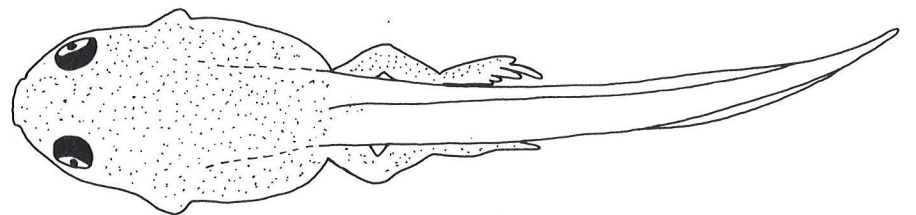
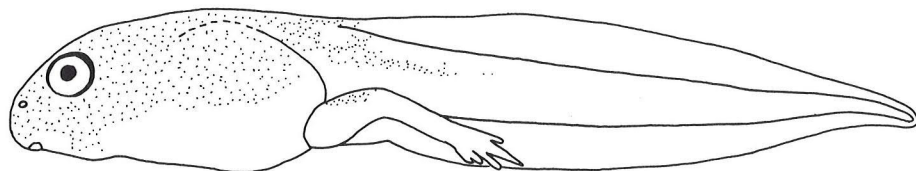


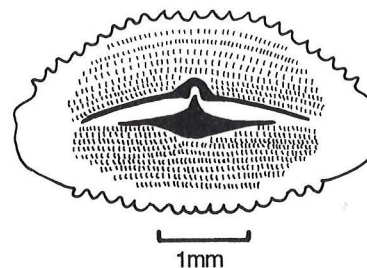
Plate 24

Body brown above transparent below; tail transparent.

Eggs terrestrial in foam nest; Tadpoles develop within the nest; November.

Max. TL 14.6mm, Stage 40

Ceratophrys cornuta



MNRJ 7845

TL 32.3mm, Stage 30

LTRF 6 - 9 (7, 8, 9) / 6 - 9 (1, 2, 3)

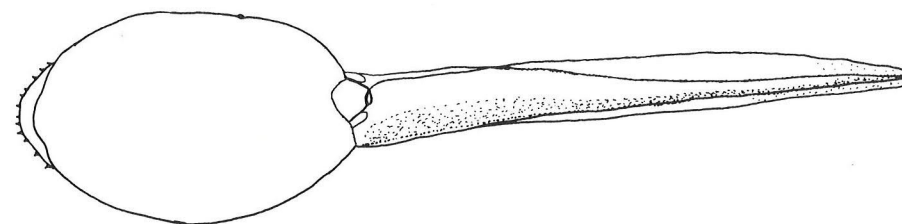
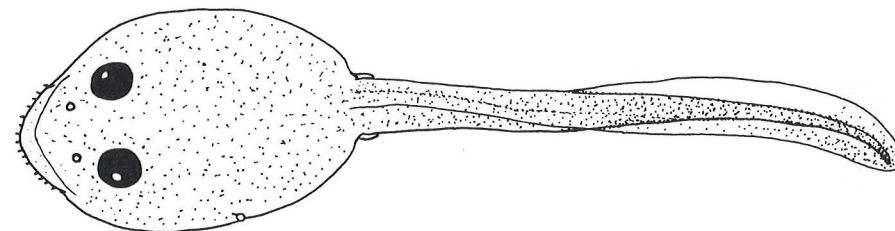
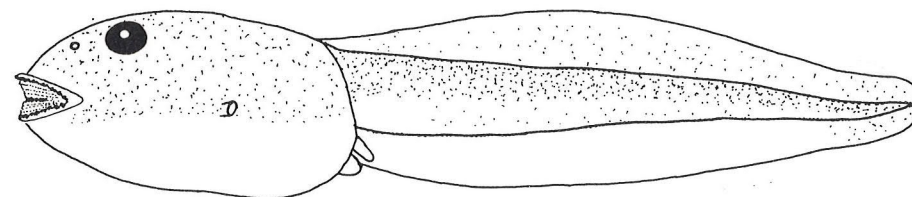


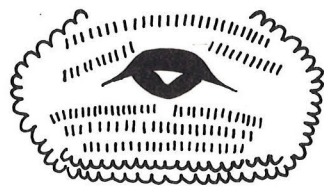
Plate 25

Body transparent olive with a silver abdomen; tail transparent olive.

Eggs aquatic ? ; Tadpoles in isolated forest ponds; March, May and October.

Max. TL 62.6mm, Stage 41

Leptodactylus fuscus / longirostris



MNRJ 7840

TL 20.5mm, Stage 28

LTRF 2 (2) / 3 [1]

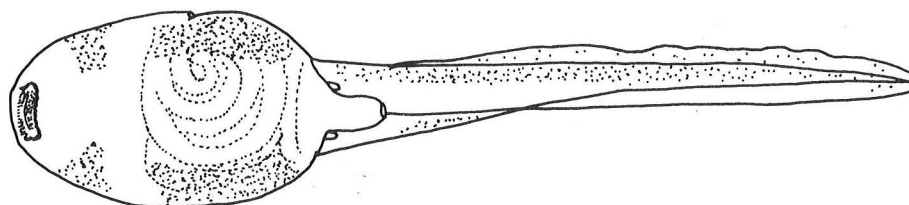
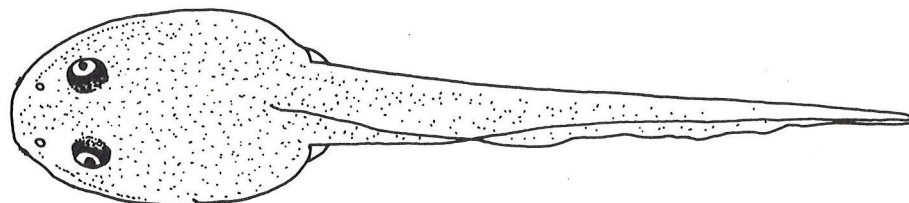
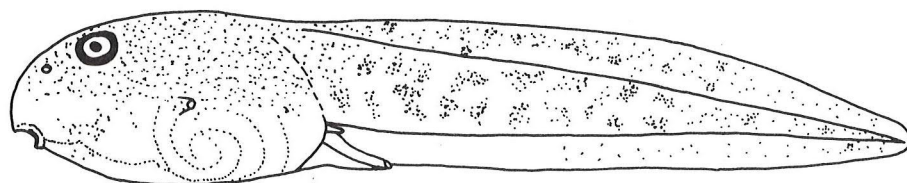


Plate 26

Body grey with a transparent abdomen; tail muscle grey, fins transparent with bluish white flecks.

Eggs terrestrial in foam nest; Tadpole in ponds, open and disturbed areas; December - January.

Max. TL 30.0mm, Stage 39

Leptodactylus knudseni



MNRJ 7841

TL 59.3mm, Stage 39

LTRF 2 (2) / 2-3 [1] [2]

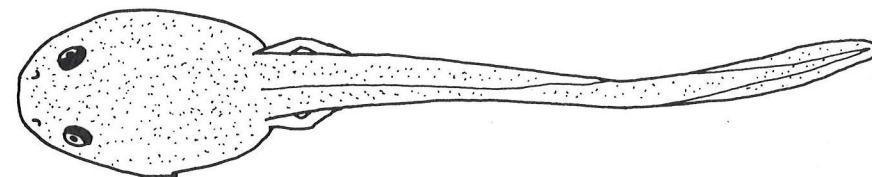
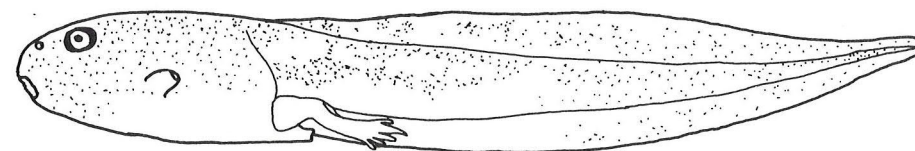


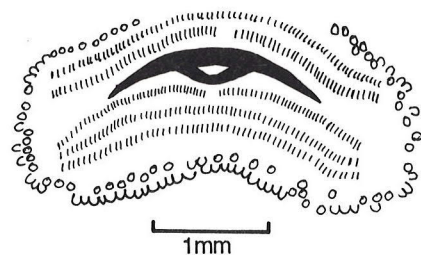
Plate 27

Body grey or dark olive with a silver abdomen, tail muscle grey or dark olive, fins transparent.

Eggs terrestrial in foam nest; Tadpole in isolated and streamside ponds; all months.

Max. TL 69.0mm, Stage 40

Leptodactylus mystaceus



MNRJ 7842

TL 37.3mm, Stage 39

LTRF 2 (2) / 3 (1)

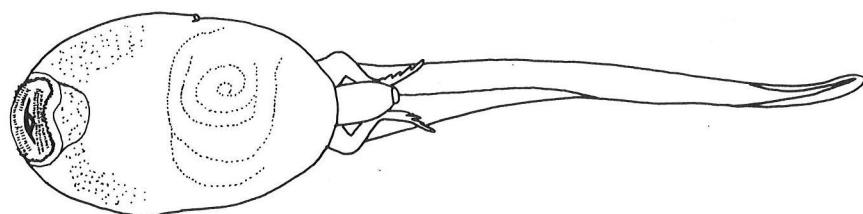
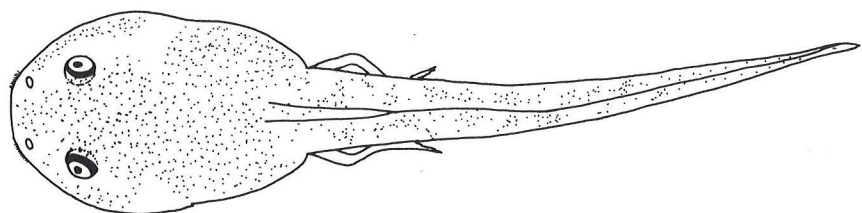
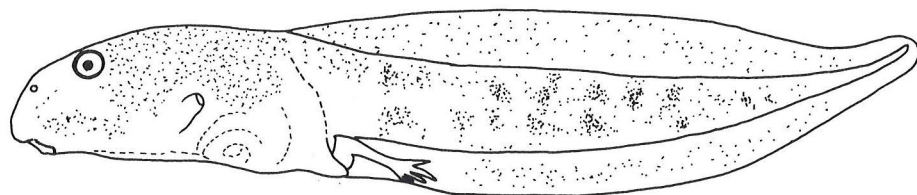


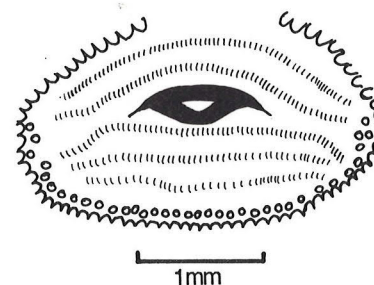
Plate 28

Body olive green with scattered white chromatophores.

Eggs terrestrial in foam nest; Tadpole in isolated forest ponds; January - April.

Max. TL 37.3mm, Stage 39

Leptodactylus ocellatus



MNRJ 7855

TL 37.9mm, Stage 38

LTRF 2 / 3

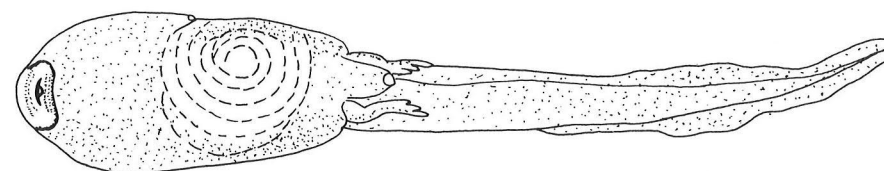
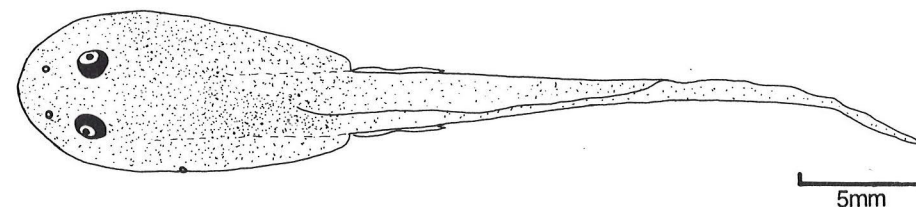
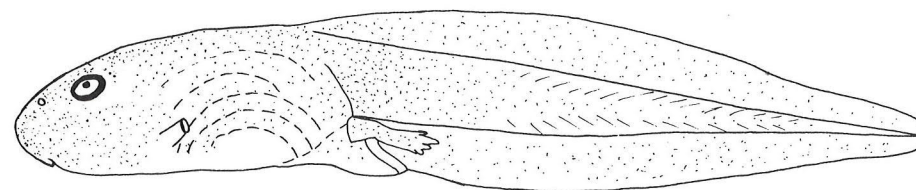


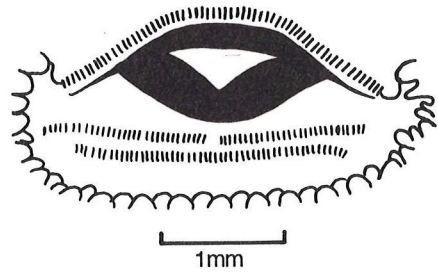
Plate 29

Body transparent olive grey; tail muscle transparent olive grey, fins transparent.

Eggs aquatic in foam nest; Tadpole in isolated ponds within Manaus; July.

Max. TL 38.0mm, Stage 39

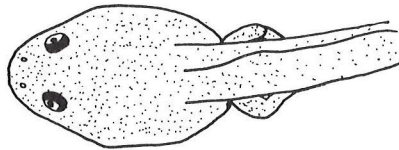
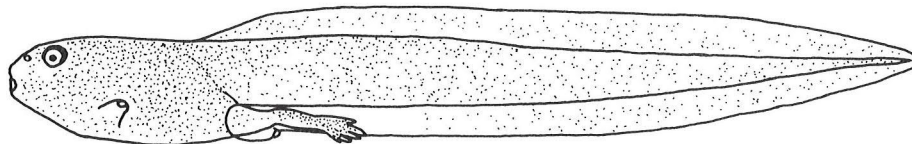
Leptodactylus pentadactylus



MNRJ 7843

TL 80.6mm, Stage 39

LTRF 1 / 2 (1)



5mm

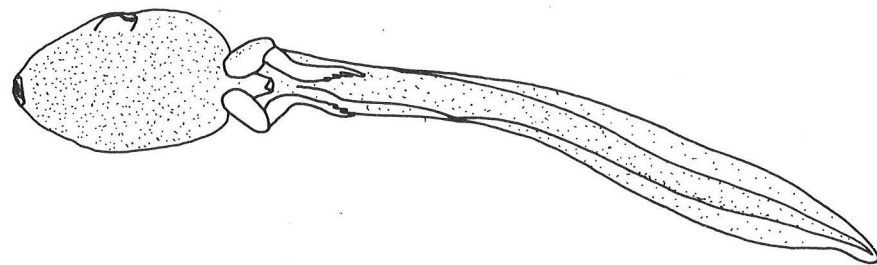
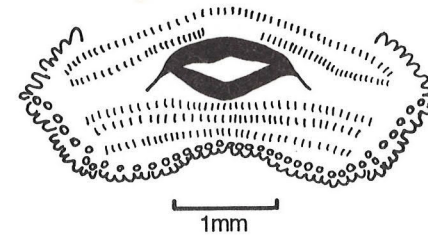


Plate 30

Body with scattered white chromatophores and a silver abdomen; tail muscle light grey, fins transparent.

Eggs terrestrial in foam nest; Tadpoles in terrestrial burrow; October - December.
Max. TL 80.6mm, Stage 39

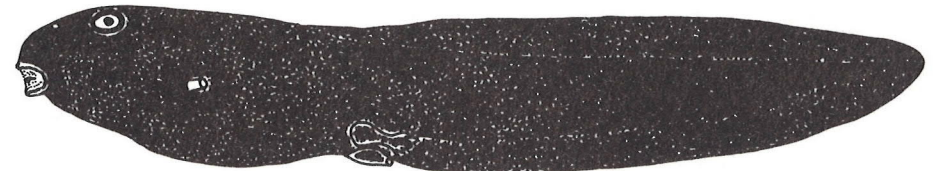
Leptodactylus rhodomystax



MNRJ 7844

TL 42.1mm, Stage 37

LTRF 2 (2) / 3



5mm



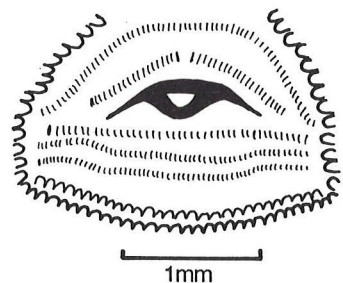
Plate 31

Body black; tail black.

Eggs terrestrial in foam nest Tadpoles in isolated and streamside ponds;
October - May.

Max. TL 49.5mm, Stage 40

Leptodactylus wagneri / *podicipinus*



MNRJ 7953

TL 30.0mm, Stage 39

LTRF 2 (2) / 3

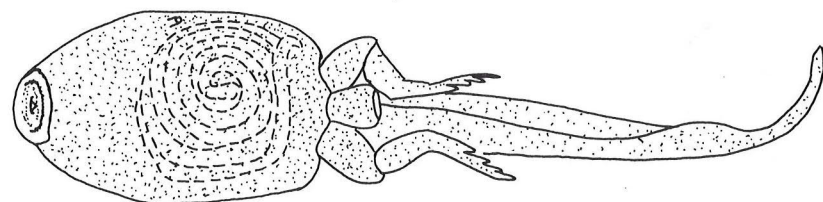
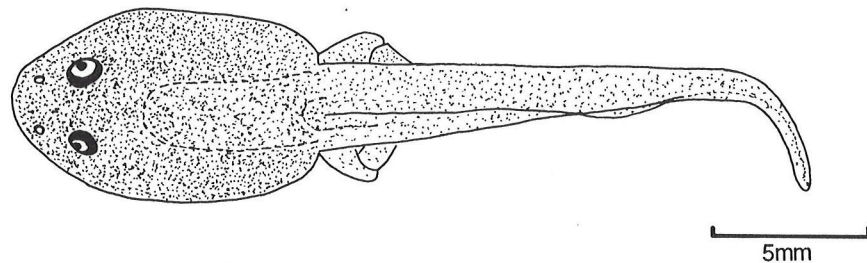
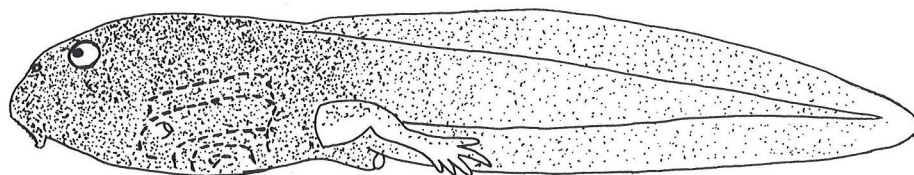


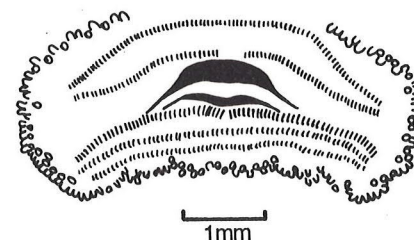
Plate 32

Body dark brown / black; tail dark brown / black but becoming lighter towards the tip of the tail.

Eggs terrestrial in foam nest; Tadpoles in isolated forest ponds; June and July.

Max. TL 30.0mm, Stage 39

Odontophrynus sp. / *Proceratophrys* sp.



MNRJ 7846

TL 35.0mm, Stage 37

LTRF 2 (2) / 3 (1)

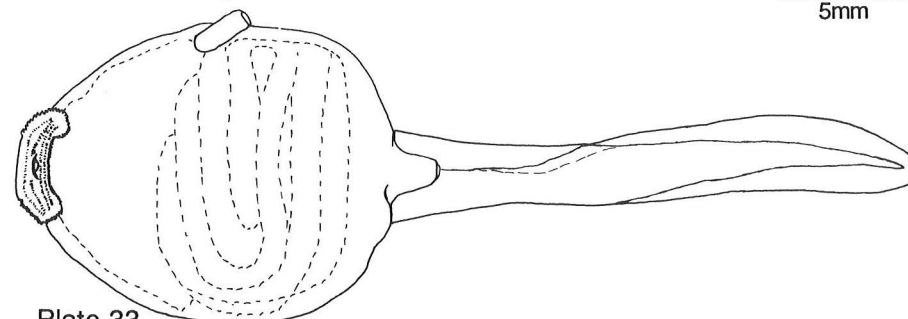
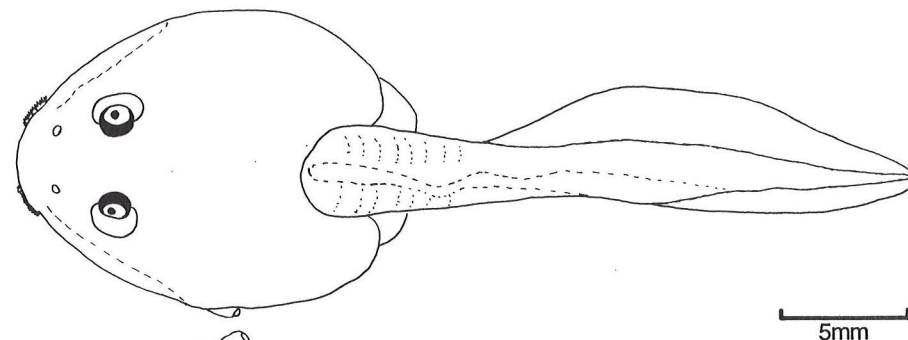
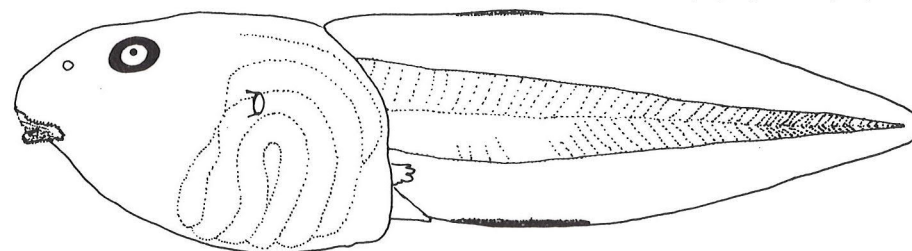


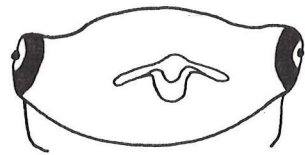
Plate 33

Body transparent olive, transparent abdomen; tail transparent.

Eggs unknown; Tadpole in isolated forest ponds; January.

Max. TL 35.0mm, Stage 37

Chiasmocleis cf. shudikarensis

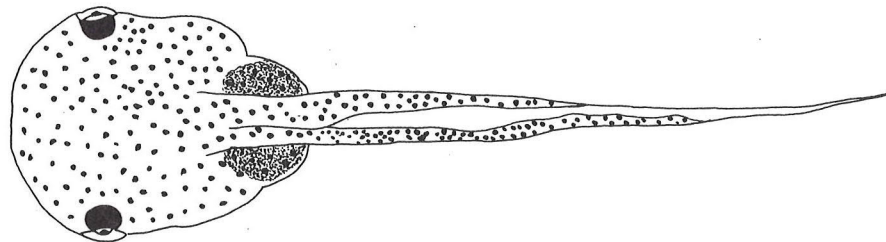
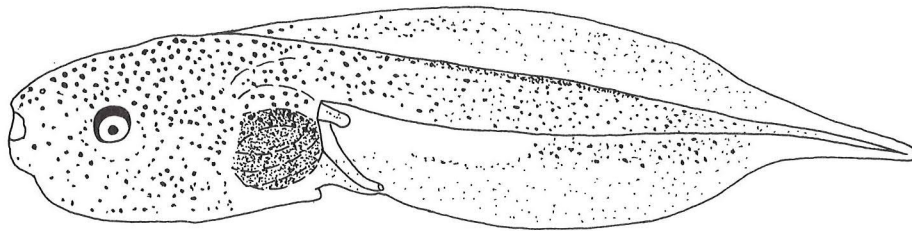


1mm

MNRJ 7954

TL 16.6mm, Stage 30

LTRF 0 / 0



5mm

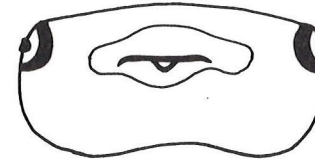
Plate 34

Body transparent; tail orange with black margins.

Eggs unknown; Tadpoles in isolated forest ponds; April - June, October.

Max. TL 16.6mm, Stage 30

Chiasmocleis cf. ventrimaculata

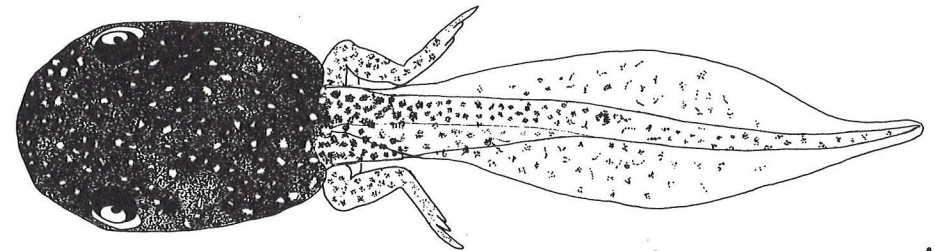
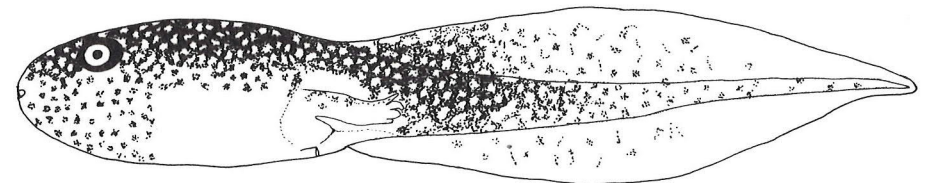


1mm

MNRJ 7847

TL 14.5mm, Stage 39

LTRF 0 / 0



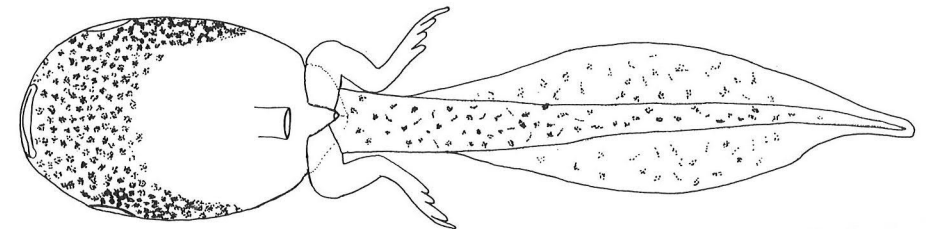
5mm

Plate 35

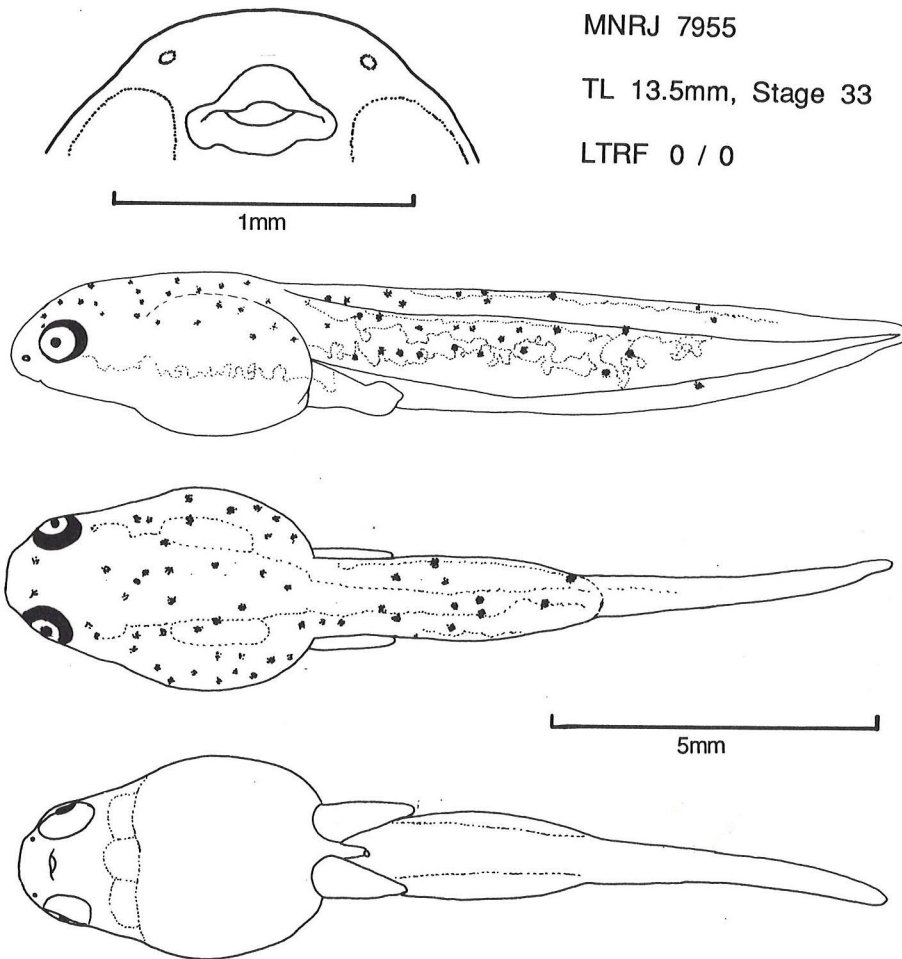
Body transparent orange; tail transparent.

Eggs aquatic; Tadpoles in streamside ponds; January, March, April, October - December.

Max. TL 14.5mm, Stage 39



Synapturanus mirandaribeiroi / salseri



MNRJ 7955

TL 13.5mm, Stage 33

LTRF 0 / 0

Plate 36

Body transparent reddish brown with scattered grey mottling and a white abdomen; tail transparent reddish brown with scattered grey mottling. Eggs terrestrial in transparent jelly nest; Tadpoles develop within the nest (non - feeding); November. Max. TL 13.5mm, Stage 33

Appendix 1:

Additional museum tadpole specimens. MNRJ = Museu Nacional do Rio de Janeiro, RJ, Brasil.

Bufo granulosus: MNRJ 7956. *B. marinus*: MNRJ 7957. *B. cf. typhonius*: MNRJ 7958. *Dendrophryniscus minutus*: MNRJ 7959. *Centrolenella oyampiensis*: MNRJ 7960. *Colostethus marchesianus*: MNRJ 7961. *Epipedobates femoralis*: MNRJ 7962. *Hyla boans*: MNRJ 7963. *H. geographica*: MNRJ 7964. *H. granosa*: MNRJ 7965. *Hyla minuta*: MNRJ 7966. *H. cf. nana*: MNRJ 7967. *Ololygon cf. rubra*: MNRJ 7968. *Osteocephalus buckleyi*: MNRJ 7969. *O. taurinus*: MNRJ 7971. *Osteocephalus* sp.: MNRJ 7970. *Phrynohyas resinifictrix*: MNRJ 7972. *Phyllomedusa bicolor*: MNRJ 7973. *P. tarsi*: MNRJ 7974. *P. tomopterna*: MNRJ 7975. *P. vaillanti*: MNRJ 7976. *Leptodactylus fuscus/longirostris*: MNRJ 7977. *L. knudseni*: MNRJ 7978. *L. mystaceus*: MNRJ 7979. *L. ocellatus*: MNRJ 7980. *L. rhodomystax*: MNRJ 7982. *L. wagneri/podicipinus*: MNRJ 7981. *Chiasmocleis cf. ventrimaculata*: MNRJ 7984. *C. shudikarensis*: MNRJ 7983.

Note: Tadpole specimens are also placed at the Departamento de Ecologia, Instituto Nacional de Pesquisas da Amazônia, Manaus, Amazonas, Brasil.

Appendix 2:

Adult specimen museum numbers. MNRJ = Museu Nacional do Rio de Janeiro, RJ, Brasil. MPEG = Museu Paraense Emilio Goeldi, Belém, Pará, Brasil.

Bufo granulosus: MNRJ 4572. *B. marinus*: MPEG 3570. *B. cf. typhonius*: MNRJ 4573; MPEG 3566. *Dendrophryniscus minutus*: MNRJ 4570, 4571; MPEG 3601 - 3603, 3583 - 3587. *Centrolenella oyampiensis*: MNRJ 4557; MPEG 3592. *Colostethus marchesianus*: MNRJ 4574; MPEG 3594. *C. sp.*: MNRJ 4575; MPEG 3633, 3634, 3581, 3582, 3633, 3634. *Epipedobates femoralis*: MNRJ 4576; MPEG 3551 - 3553. *Hyla boans*: MNRJ 4554, 4555; MPEG 3642, 3643. *H. geographica*: MNRJ 4553. *H. granosa*: MNRJ 4556; MPEG 3604, 3605. *H. lanciformis*: MNRJ 4552; MPEG 3644. *H. minuta*: MPEG 3614. *Ololygon cf. rubra*: MNRJ 7999; MPEG 3615. *O. garbei*: MNRJ 7848; MPEG 3646. *Osteocephalus taurinus*: MNRJ 4551; MPEG 3547 - 3549, 3591. *O. sp.*: MNRJ 4550, 4549; MPEG 3623 - 3625. *Phyllomedusa tomopterna*: MNRJ 4558; MPEG 3645. *Adenomera andreae*: MNRJ 4565; MPEG 3590, 3554, 3595, 3597. *Eleutherodactylus fenestratus*: MNRJ 4567; MPEG 3611, 3571 - 3573, 3550. *E. sp. 1*: MPEG 3626, 3627, 3596. *Leptodactylus fuscus/longirostris*: MPEG 3613, 3619. *L. knudseni*: MNRJ 4992. *L. mystaceus*: MNRJ 7995. *L. ocellatus*: MNRJ 7998. *L. pentadactylus*: MNRJ 4559. *L. rhodomystax*: MNRJ 4560, 4561. *L. riveroi*: MNRJ 4563; MPEG 3622. *L. stenodema*: MNRJ 4562. *L. wagneri/podicipinus*: MNRJ 4564; MPEG 3621. *Lithodytes lineatus*: MNRJ 4566. *Chiasmocleis cf. ventrimaculata*: MNRJ 4568, 4569. *Elachistocleis ocalis*: MNRJ 7996. *Synapturanus mirandaribeiroi*: MPEG 3568, 3569. *Pipa arrabali*: MNRJ 4577.

Appendix 3:

A computer based, interactive key to tadpoles occurring in the central Amazon rainforest, Manaus, Amazonas, Brasil

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Introduction

The following interactive computer programs were constructed to accompany the dichotomous key to aquatic tadpoles presented. The programs are in BASIC and run on any IBM-PC (XT or AT).

The running program asks 11 questions regarding a tadpole to be identified (Table 1). The resulting data set is compared with the existing data matrix which contains the known species of the region (Table 2) and gives a list of species from the data matrix whose characteristics are or could be equivalent (Table 3).

An additional program allows the dimensions to be modified (i. e. add or change the questions and/or the existing data matrix). Consequently an entirely new file can be started using a completely new set of questions and/or species.

The existing questions and data matrix of tadpoles described herein are presented below (Tables 1 - 3). Copies of the programs with instructions on their usage are available by writing to the first author.

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Table 1: Example of the running program where 11 questions are asked regarding the tadpole to be identified.

Running Program

A) What is the type of oral apparatus?

1. Oral disc with jaws, labial teeth and marginal papillae
2. Oral disc with jaws and marginal papillae, but without labial teeth
3. Oral disc with oral flaps, without papillae or keratinized mouthparts

Please type a number between 0 and 3:

B) What is the configuration of the marginal oral disc papillae?

1. Complete around the oral disc
2. Dorsal gap, papillae overlap A1
3. Dorsal gap, papillae do not overlap A1
4. Dorsal and ventral gap
5. Papillae present, but none of the above
6. Papillae absent

Please type a number between 0 and 6:

C) Are submarginal papillae present?

1. Yes
2. No

Please type a number between 0 and 2:

D) Where is the spiracle located?

1. On the left side (sinistral)
2. On the belly or chest (medioventral)
3. Low on left side but not medioventral (paragyrinid)

Please type a number between 0 and 3:

E) Where is the vent tube located?

1. Medial
2. Dextral (free of tail fin)
3. Dextral (attached to tail fin)

Please type a number between 0 and 3:

F) What is the relative eye location?

1. Dorsal
2. Dorsolateral
3. Lateral

Please type a number between 0 and 3:

G) How many rows of labial teeth occur on the anterior labium?

- | | |
|----------|----------|
| 1. None | 6. Five |
| 2. One | 7. Six |
| 3. Two | 8. Seven |
| 4. Three | 9. Eight |
| 5. Four | 10. Nine |

Please type a number between 0 and 10:

Table 1: continued.

- H) Which rows of labial teeth on the anterior labium have median gaps?
- | | |
|--------------|---------------------------------------|
| 1. None | 5. A2 |
| 2. A1 | 6. A3 |
| 3. A1 and A2 | 7. Gaps present but none of the above |
| 4. A1 and A3 | |

Please type a number between 0 and 7:

- I) How many rows of teeth occur on the posterior (lower) labium?

- | | |
|----------|----------|
| 1. None | 6. Five |
| 2. One | 7. Six |
| 3. Two | 8. Seven |
| 4. Three | 9. Eight |
| 5. Four | 10. Nine |

Please type a number between 0 and 10:

- J) Which rows of labial teeth on the posterior labium have median gaps?

- | | |
|--------------|---------------------------------------|
| 1. None | 4. P1, P2 and P3 |
| 2. P1 | 5. Gaps present but none of the above |
| 3. P1 and P2 | |

Please type a number between 0 and 5:

- K) Where was the tadpole collected?

- | |
|---|
| 1. Stream or lake |
| 2. Streamside pond |
| 3. Isolated forest pond |
| 4. Arboreal waterbody (eg. bromeliad, treehole) |
| 5. Isolated terrestrial nest |
| 6. Open / disturbed area |

Please type a number between 0 and 6:

Table 2: Existing data matrix for tadpoles of the Manaus region, Amazonas, Brasil.

Notes: If a species has more than one answer, the digits of the possible answers should be entered in increasing order (e.g. species y can be found in lakes, isolated ponds and in open/disturbed areas. These three places have the numbers 1, 3, and 6 respectively in the answers list. You would type "136" as a key matrix entry.) Note; 0 is the 10th answer.

If you do not have data for answering a question you can type <CR>, this is considered a "no response" and is handled accordingly. If you do not know how to qualify a species within a question (e.g. you don't know if species x occurs in a particular habitat or, it can be found everywhere) you have the option "-1" which allows the program to select this species regardless of the answer the user types in for that question.

Data Matrix

<i>Bufo granulosus</i>	1	4	2	1	1	2	3	5	3	1	6
<i>Bufo marinus</i>	1	4	2	1	1	2	3	5	4	1	6
<i>Bufo cf. typhonius</i>	1	4	2	1	1	2	3	5	4	1	2
<i>Dendrophryniscus minutus</i>	1	4	2	1	1	2	3	1	4	1	2
<i>Centrolenella oyampiensis</i>	1	3	2	1	1	1	1	1	2	1	1
<i>Colostethus marchesianus</i>	1	3	2	1	3	2	3	5	4	2	23
<i>Epipedobates femoralis</i>	1	3	2	1	3	2	3	5	4	2	3
<i>Hyla boans</i>	1	2	1	1	3	2	3	5	45	2	1
<i>Hyla cf. parviceps</i>	2	5	2	1	2	2	1	1	1	1	-1
<i>Hyla geographica</i>	1	2	1	1	3	2	34	2456	456	12	12
<i>Hyla granosa</i>	1	2	2	1	3	2	3	3	45	23	12
<i>Hyla minuta</i>	1	2	2	1	2	3	1	1	23	1	6
<i>Hyla cf. nana</i>	2	1	2	1	3	2	1	1	1	1	2
<i>Hyla sp. 1</i>	2	5	1	1	2	3	1	1	1	1	-1
<i>Ololygon rubra</i>	1	2	1	1	2	3	3	35	4	12	6
<i>Osteocephalus buckleyi</i>	1	2	1	1	3	2	3	5	345678	12	1
<i>Osteocephalus taurinus</i>	1	2	1	1	3	2	3	5	45678	2	23
<i>Osteocephalus sp.</i>	1	2	1	1	3	23	5	4	12	4	0
<i>Phrynohyas resinifictrix</i>	1	2	1	1	1	2	3	5	456	1	4
<i>Phyllomedusa bicolor</i>	1	2	1	3	2	3	3	5	34	2	23
<i>Phyllomedusa tarsius</i>	1	2	1	3	2	3	3	5	34	12	3
<i>Phyllomedusa tomopterna</i>	1	2	2	3	2	3	3	5	34	12	3
<i>Phyllomedusa vaillanti</i>	1	2	1	3	2	3	3	5	34	12	12
<i>Ceratophrys cornuta</i>	1	1	2	1	2	2	7890	7	7890	4	3
<i>Leptodactylus fuscus/longirostris</i>	1	2	1	1	1	2	3	5	4	12	6
<i>Leptodactylus knudseni</i>	1	2	2	1	1	2	3	5	3	23	3
<i>Leptodactylus mystaceus</i>	1	2	1	1	1	2	3	5	4	2	3
<i>Leptodactylus cf. ocellatus</i>	1	2	1	1	1	2	3	1	4	1	6
<i>Leptodactylus pentadactylus</i>	1	2	2	1	1	2	2	1	3	2	5
<i>Leptodactylus rhodomystax</i>	1	2	1	1	1	2	3	5	4	1	23
<i>Leptodactylus wagneri/podicipinus</i>	1	2	1	1	1	2	3	5	4	1	23
<i>Odontophrynus sp./Proceratophrys sp.</i>	1	2	1	1	1	2	3	5	4	2	3
<i>Chiasmocleis cf. ventrimaculata</i>	3	6	2	3	1	2	1	1	1	1	2
<i>Chiasmocleis cf. shudikarensis</i>	3	6	2	3	2	2	1	1	1	1	3
<i>Synapturanus sp.</i>	3	6	2	3	1	2	1	1	1	1	5

Table 3: Example of final printout for a tadpole identification.

In the following example, the typed answers for each question are 1, 2, 1, 3, 2, 3, 3, 5, 3, 2, and 3 respectively.

Note: If none of the species in the data matrix match with the tadpole species to be identified the result is:

“No such species exists”.

POSSIBLE SPECIES ARE:

Phyllomedusa bicolor

Phyllomedusa tarsius